OPERATING AND SERVICE MANUAL

HP 11729C
CARRIER NOISE TEST SET
(Including Options 003, 007, 011, 015, 019, 023, 027, 130 and 140)

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 2509A.

For additional important information about serial numbers, see INSTRUMENTS COVERED BY THIS MANUAL in Section I.

HEWLETT PACKARD

E. 24001 MISSION AVE., TAF C-34, SPOKANE, WASHINGTON, U.S.A. 99220

OPERATING AND SERVICE MANUAL PART NUMBER: 11729-90017
MICROFICHE PART NUMBER: 11729-90018

Printed: MARCH 1985

SAFETY CONSIDERATIONS

GENERAL

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

This product is a Safety Class I instrument (provided with a protective earth terminal).

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

SAFETY EARTH GROUND

An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set.

WARNINGS

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection.) In addition, verify that a common ground exists between the unit under test and this instrument prior to energizing either unit.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

Servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc.). Do not use repaired fuses or short circuited fuseholders.

SAFETY SYMBOLS

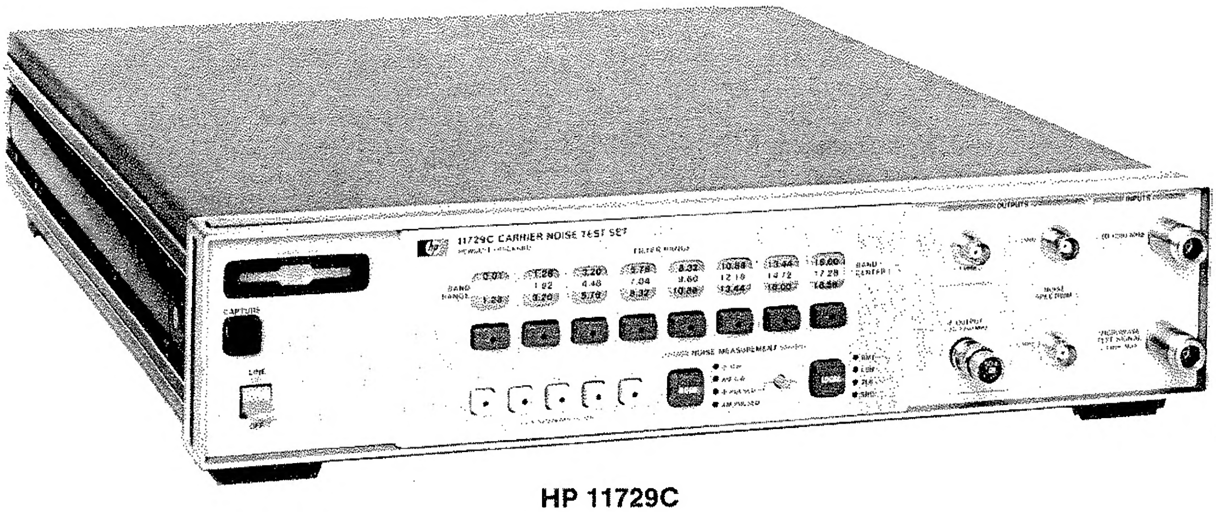
⚠ Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (see Table of Contents for page references).

ϟ Indicates hazardous voltages.

⏚ Indicates earth (ground) terminal.

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

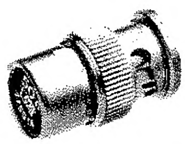


HP 11729C

CABLE AND ATTENUATOR

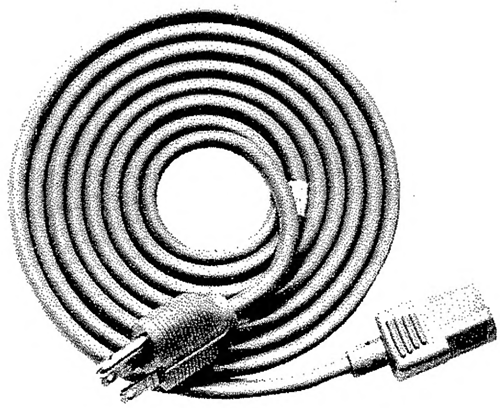
Cable-attenuator assembly used to configure the internal 640 MHz oscillator.

SMA TERMINATION



BNC TERMINATION

The 50Ω termination is installed on the IF OUTPUT port as shown in the photograph.



POWER CABLE

Figure 1-1. HP Model 11729C Carrier Noise Test Set with Accessories Supplied

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

This manual contains information required to install, operate, test, adjust and service the Hewlett-Packard Model 11729C Carrier Noise Test Set. Figure 1-1 shows the Carrier Noise Test Set with all of its externally supplied accessories.

The Carrier Noise Test Set Operating and Service manual has eight sections. The subjects addressed are:

Section I, General Information
Section II, Installation
Section III, Operation
Section IV, Performance Tests
Section V, Adjustments
Section VI, Replaceable Parts
Section VII, Manual Changes
Section VIII, Service

Listed on the title page of this manual, below the manual part number, is a microfiche part number. This number may be used to order 100 x 150 millimetre (4 x 6 inch) microfilm transparencies of this manual. Each microfiche contains up to 96 photo-duplicates of the manual pages. The microfiche package also includes the latest Manual Changes supplement, as well as all pertinent Service Notes.

1-2. SPECIFICATIONS

Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument may be tested. Supplemental characteristics are listed in Table 1-2. Supplemental characteristics are not warranted specifications, but are typical characteristics included as additional information for the user. Typical system performance when using the Carrier Noise Test Set with the HP 8662A or 8663A is given in Table 1-3.

1-3. SAFETY CONSIDERATIONS

This product is a Safety Class I instrument, that is, one provided with a protective earth terminal. The Carrier Noise Test Set and all related documentation should be reviewed for familiarization with safety markings and instructions before operation. Refer to the Safety Considerations page found at the beginning of this manual for a summary of the safety information. Safety information for installation, operation, performance testing, adjustment, or service is found in appropriate places throughout this manual.

1-4. INSTRUMENTS COVERED BY THIS MANUAL

Attached to the rear panel of the instrument is a serial number plate. The serial number is in the form: 0000A00000. The first four digits and the letter are the serial number prefix. The last five digits are the suffix. The prefix is the same for identical instruments; it changes only when a configuration change is made to the instrument. The suffix however, is assigned sequentially and is different for each instrument. The contents of this manual apply directly to instruments having the serial number prefix(es) listed under SERIAL NUMBERS on the title page.

1-5. MANUAL CHANGES SUPPLEMENT

An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates that the instrument is different from those documented in this manual. The manual for this newer instrument is accompanied by a Manual Changes supplement. The supplement contains "change information" that explains how to adapt this manual to the newer instrument.

In addition to change information, the supplement may contain information for correcting errors in the manual. To keep the manual as current and as accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement is identified with the manual print date and part number, both of which appear on the manual title page. Complimentary copies of the supplement are available from Hewlett-Packard.

For information concerning a serial number prefix that is not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-6. DESCRIPTION

The Hewlett-Packard Model 11729C Carrier Noise Test Set is an integral part of a phase noise measurement system.

The Carrier Noise Test Set can perform the following operations:

- Up converts an external (or internal) reference signal.

DESCRIPTION (cont'd)

- Down converts the signal under test to an intermediate frequency (IF).
- Phase demodulates the phase noise of the test signal using the Phase Detector Method.
  - —When the Phase Detector Method is used the signal under test is phase locked to a reference signal.
  - —The signal under test is then phase detected against the same reference signal.
- Frequency demodulates the phase noise of the test signal using the Frequency Discriminator Method.

With the addition of Option 130 the Carrier Noise Test Set is capable of detecting the signal under test for making AM noise measurements.

The Carrier Noise Test Set can be used in two methods of making phase noise measurements:

- Phase Detector Method
- Frequency Discriminator Method

The number of drive signals required for the Carrier Noise Test Set to be completely operational depends on the phase noise measurement method used and the frequency of the signal under test. The drive signals are supplied from an external RF source.In addition to the external RF source, one of the drive signals (640 MHz) can be supplied by the Carrier Noise Test Set. The Carrier Noise Test Set can be configured to provide an internally generated 640 MHz signal; the 640 MHz signal is available by connecting the provided cable-attenuator assembly (HP 11729-60096 or HP 11729-60098 [Option 140]) between two rear panel connectors. The absolute system noise floor will be degraded close-in to the carrier when using the internally generated 640 MHz signal, compared to the 640 MHz signal being supplied by the HP 8662A Synthesized Signal Generator.

The following table lists when the drive signals are required:

Drive Signals	Phase Detector Method		Frequency Discriminator Method	
	Frequency Range of Signal Under Test		Frequency Range of Signal Under Test	
	10 MHz to 1.28 GHz	1.28 GHz to 18 GHz	10 MHz to 1.28 GHz	1.28 GHz to 18 GHz
Fixed 640 MHz	Not Needed	X	Not Needed	X
Tunable 5 MHz—1280 MHz	X	X	Not Needed	Not Needed

X = Drive signal is used.

When using the Phase Detector Method the signal under test is first down-converted to the 5 MHz—1280 MHz range and then phase detected against the tunable 5 MHz—1280 MHz signal. Phase detecting produces a dc signal with simultaneous ac voltage fluctuations. These ac components are proportional to the combined phase noise of the two input signals (the signal under test and the tunable 5 MHz—1280 MHz signal), at rates corresponding to the offset frequency from the signal under test. The phase detected output signal is also used as an error voltage to keep the signal under test and the tunable 5 MHz—1280 MHz signal in phase quadrature (that is, 90 degrees out-of-phase).

When using the Frequency Discriminator Method, the down-converted signal under test is phase detected against itself using an external delay line and the internal mixer/phase detector. The phase detected signal is proportional to the phase noise on the signal under test. In the Frequency Discriminator Method the signal under test does not have to be phase locked to an external reference signal.

The Carrier Noise Test Set accepts test signals from 10 MHz—18 GHz, at a level of +7 dBm to +20 dBm. The broad frequency range is user selectable from the front panel (local) or by using the Hewlett-Packard Interface Bus (remote). When using the Carrier Noise Test Set in the Phase Detector Method the controls for acquiring and maintaining phase lock are user selectable from the front panel (local) or by using the Hewlett-Packard Interface Bus (remote).

The Carrier Noise Test Set is compatible with HP-IB to the extent indicated by the following codes: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP1, DC1, DT0, and C0. The Carrier Noise Test Set interfaces with the bus via three-state TTL circuitry. An explanation of the compatibility code can be found in IEEE Standard 488 (1978), "IEEE Standard Digital Interface for Programmable Instrumentation" or the identical ANSI Standard MC1.1.

1-7. OPTIONS

1-8. Electrical Options

Option 003. Option 003 has two bands installed, 10 MHz to 1.28 GHz and 1.28 GHz to 3.2 GHz.

Option 007. Option 007 has two bands installed, 10 MHz to 1.28 GHz and 3.2 GHz to 5.76 GHz.

Electrical Options (cont'd)

Option 011. Option 011 has two bands installed, 10 MHz to 1.28 GHz and 5.76 GHz to 8.32 GHz.

Option 015. Option 015 has two bands installed, 10 MHz to 1.28 GHz and 8.32 GHz to 10.88 GHz.

Option 019. Option 019 has two bands installed, 10 MHz to 1.28 GHz and 10.88 GHz to 13.44 GHz.

Option 023. Option 023 has two bands installed, 10 MHz to 1.28 GHz and 13.44 GHz to 16.00 GHz.

Option 027. Option 027 has two bands installed, 10 MHz to 1.28 GHz and 16.00 GHz to 18.00 GHz.

Option 130. Option 130 adds AM noise measurement capabilities.

Option 140. Option 140 places all front panel connectors on the rear panel.

1-9. Mechanical Options

The following options may have been ordered and received with the Carrier Noise Test Set. If they were not ordered with the original shipment and are now desired, they can be ordered from the nearest Hewlett-Packard office using the part numbers included in each of the following paragraphs.

Instrument Slide Kit (Option 160). The Carrier Noise Test Set can be easily removed from the instrument rack by using the instrument slide kit. The part number of the slide kit is HP 1494-0026.

Front Handle Kit (Option 907). Ease of handling is increased with the front panel handles. The Front Handle Kit part number is HP 5061-0088.

Rack Flange Kit (Option 908). The Carrier Noise Test Set can be solidly mounted to the instrument rack using the flange kit. The Rack Flange Kit part number is HP 5061-9674.

Rack Flange and Front Handle Combination Kit (Option 909). This is a unique part which combines both functions. It is not simply a front handle kit and a rack flange kit packaged together. The Rack Flange and Front Panel Combination Kit part number is HP 5061-9675.

1-10. ACCESSORIES SUPPLIED

The accessories supplied with the Carrier Noise Test Set are shown in Figure 1-1.

a. The line power cable is supplied in several configurations, depending on the destination of the original shipment. Refer to Power Cables in Section II of this manual.

b. An additional fuse is shipped only with instruments that are factory configured for 100/120 Vac operation. This fuse has a 0.5A rating and is for reconfiguring the instrument for 220/240 Vac operation.

c. A 50 ohm BNC termination is supplied to be connected to the IF OUTPUT on the front panel. With the 50 ohm termination in place the Carrier Noise Test Set meets the requirements of MIL STD 461 RE02.

NOTE

The 50 ohm termination must be connected to the IF OUTPUT if the IF OUTPUT is not being used.

d. The Carrier Noise Test Set has two connectors on the rear panel labeled 640 MHz OUT and 640 MHz IN. The 640 MHz OUT is connected to the 640 MHz IN to configure the internally generated 640 MHz signal for use during a measurement. A cable-attenuator assembly (HP 11729-60096 or HP 11729-60098 [Option 140]) is supplied to make this connection. The length and attenuation of this cable assembly is critical for the generation of the 640 MHz signal.

e. A 50Ω SMA termination is supplied to be connected to the 640 MHz OUT connector on the rear panel. For proper operation of an amplifier, in the Carrier Noise Test Set, the termination must be in place when the 640 MHz OUT connector is not being used.

1-11. EQUIPMENT REQUIRED BUT NOT SUPPLIED

For the Carrier Noise Test Set to be completely operational it will require one or two drive signals (either a fixed 640 MHz signal or a 5 MHz—1280 MHz signal or both) that are supplied from an external RF source. Critical specifications of the RF source are in Table 1-4 in this section.

If desired the 640 MHz drive signal can be supplied by the Carrier Noise Test Set. On the rear panel of the Carrier Noise Test Set the 640 MHz OUT connector is connected to the 640 MHz IN connector, using the cable-attenuator assembly (HP 11729-60096 or HP 11729-60098 [Option 140]) supplied with the instrument. The absolute system noise floor will be degraded close-in to the carrier when

EQUIPMENT REQUIRED BUT NOT SUPPLIED (cont'd)

using the internally generated 640 MHz signal, compared to the 640 MHz signal being supplied by the HP 8662A Synthesized Signal Generator.

The following table lists the coaxial cables required to connect the Carrier Noise Test Set to the HP 8662A or 8663A Synthesized Signal Generators. Also listed are the cables necessary to connect the Carrier Noise Test Set to a spectrum analyzer.

HP Part No.	Description	Use on Carrier Noise Test Set
11170B	BNC(M)-BNC(M) (24 inches)	5 to 1280 MHz INPUT
11170C	BNC(M)-BNC(M) (48 inches)	640 MHz IN FREQ-CONT DC-FM FREQ-CONT X-OSC NOISE SPECTRUM <10 MHz OUTPUT <1 MHz OUTPUT

Table 1-1. Specifications (1 of 2)

Electrical Characteristics	Performance Limits	Conditions
TEST SIGNAL		
Frequency Range[1]	10 MHz to 18 GHz	External low-pass filtering may be required for test signals <20 MHz and ±20 MHz around band centers
Band Center Frequencies	1.92 GHz 4.48 GHz 7.04 GHz 9.60 GHz 12.16 GHz 14.72 GHz 17.28 GHz	
IF OUTPUT		
Bandwidth	5 MHz to 1280 MHz	
Level	+7 dBm Minimum	
AM NOISE DETECTION (Option 130)		
Frequency Range	10 MHz to 18 GHz	
Input level	0 dBm to +18 dBm	
AM Noise Floor		At +10 dBm input level
Offset from Carrier (Hz)	AM Noise (dBc/Hz)	
1k	−138	
10k	−145	
100k	−155	
1M	−160	
RESIDUAL NOISE		
Offset From Carrier(Hz)	dBc/Hz	With a <1.28 GHz input signal
10	−115	
100	−126	
1k	−135	
10k	−142	
100k	−151	
1M	−156	

[1]In eight (8) bands, excluding ±5 MHz around band center frequencies.

Table 1-1. Specifications (2 of 2)

Electrical Characteristics	Performance Limits	Conditions
RESIDUAL NOISE (cont'd)		
Offset From Carrier (Hz)	dBc/Hz	With a 10 GHz input signal
10	−90	
100	−105	
1k	−115	
10k	−127	
100k	−137	
1M	−142	
GENERAL		
Line Voltage	100,120,220 or 240V (+5%,−10%)	
Line Frequency	48 to 66 Hz	
Power Dissipation	75 V·A maximum	
Temperature:		
Operating	0 to +55°C	
Weight:		
Net	10.4 kg (23 lb.)	
Dimensions[2]:		
Height	99 mm (3.9 in.)	
Width	425 mm (16.8 in.)	
Depth	551 mm (21.7 in.)	
Remote Operation (HP-IB)[3]		
IEEE STD 488-1978 Compatibility Code: SH1, AH1, T5,TE0, L3, LE0, SR1, RL1,PP1, DC1, DT0,C0.		
ELECTROMAGNETIC COMPATIBILITY		
Electromagnetic Interference	Conducted and radiated interference is within the requirements of CE03 and RE02 as called out in MIL-STD 461, and within the requirements of VDE 0871 and CISPR Publication 11.	

[2]For ordering cabinet accessories the module sizes are 3-1/2H, 1MW (module width), 20D.

[3]The Hewlett-Packard Interface Bus (HP-IB) is Hewlett-Packard's implementation of IEEE STD 488-1978, "Digital Interface for Programmable Instrumentation." All front panel functions with the exception of the line switch are HP-IB programmable.

Table 1-2. Supplemental Characteristics (1 of 2)

Supplemental characteristics are intended to provide information useful in applying the instrument by giving typical, but non-warranted, performance parameters.

TEST SIGNAL

Level: For test signals >1.28 GHz: +7 dBm to +20 dBm Typically useable down to −15 dBm with potential noise floor degradation.

For test frequencies <1.28 GHz: −5 dBm to +10 dBm. Typically usable down to −15 dBm with potential noise floor degradation; optimal level from −2 dBm to +3 dBm.

IF OUTPUT

Typically useable to 1500 MHz dependent on the test frequency.

NOISE SPECTRUM OUTPUTS

<10 MHz Output (The < 10 MHz Output is amplified by an internal 40 dB Low Noise Amplifier)

Bandwidth: 10 Hz to 10 MHz. (3 dB BW: 10 Hz to 15 MHz typical.)

Flatness: ±1 dB typical, 50 Hz to 10 MHz

Output Impedance: 50Ω nominal

<1 MHz Output (The < 1 MHz Output is a non-amplified output)

Bandwidth: dc to 1 MHz. (3 dB BW: dc to 1.5 MHz typical.)

Flatness: ± 1 dB typical

Output impedance: 600Ω nominal

Auxiliary Noise

Output impedance: 600Ω nominal

Bandwidth: dc to 1 MHz typical

PHASE LOCK LOOP FUNCTION

FREQUENCY CONTROL OUTPUTS

Freq-Cont X-Osc

Output level: ±10V nominal

Nominal Output impedance: 100Ω.

Freq-Cont DC-FM

Output level: ±1V nominal

Nominal Output impedance: 50Ω.

Lock Bandwidth Factor: 1, 10, 100, 1k, 10k nominal. (Selectable by front panel pushbuttons.)

Loop characteristics: dependent on method of phase lock (crystal or DC-FM) used and loop VCO chosen.

Loop Characteristics when using the HP 8662A Electronic Frequency Control input for phase locking with the HP 8662A front panel output at 0 dBm:

Loop Holding Range (LHR):

$$\frac{\pm f_{dut}}{10^7} \quad \text{(Hz nominal)}$$

Loop Bandwidth (LBW):

$$\frac{\text{HP 11729C LBF x } f_{dut}}{10^{10}} = \text{(Hz nominal)}$$

Loop Bandwidth Maximum: 2 kHz typical

f = frequency
dut = Device under test
LBF = Lock Bandwith Factor set on HP 11729C

Loop Characteristics when using the HP 8662A dc FM modulation input for phase locking with the HP 8662A front panel output at 0 dBm:

Loop Holding Range (LHR): ± FM deviation set on HP 8662A (Hz nominal).

Loop Bandwidth (LBW):

$$\frac{\text{(HP 8662A FPD) x HP 11729C LBF nom.}}{10^3} = \text{(Hz nom.)}$$

Loop Bandwidth Maximum: 100 kHz typical.

LBF = Lock Bandwidth Factor set on HP 11729C
FPD = Front Panel Deviation

LOOP TEST PORTS

Loop Test Input:

Source: random noise source, tracking generator, or sinusoidal input.

Bandwidth: dc to 100 kHz typical.

Input level: less than 0.1V peak, typical.

Input impedance: dc coupled, 10 kΩ nominal

Loop Test Output:

Bandwidth: dc to 100 kHz, typical.

Output level: gain outside loop bandwidth = 1

Output impedance: dc coupled, 1 kΩ. nominal

AM NOISE DETECTION (Option 130)

AM Noise Floor (at +10 dBm input level):

Offset From Carrier (Hz)	Typical AM Noise(dBc/Hz)
1k	−147
10k	−152
100k	−161
1M	−165

Table 1-2. Supplemental Characteristics (2 of 2)

RESIDUAL NOISE

Offset from carrier (Hz)	Carrier			
	<1.28GHz (dBc/Hz)	5 GHz (dBc/Hz)	10 GHz (dBc/Hz)	18 GHz (dBc/Hz)
10	−125	−112	−106	−100
100	−133	−120	−116	−110
1k	−140	−130	−125	−119
10k	−147	−137	−132	−126
100k	−156	−146	−141	−135
1M	−160	−148	−144	−138
10M	−160	−148	−144	−138

The absolute phase noise of the internal saw oscillator with a 10 GHz input signal.

Offset From Carrier (Hz)	dBc/Hz
1k	−86
10k	−116
100k	−135
1M	−145
10M	−147

Sensitivity of the HP 11729C using the internal saw oscillator and a 10 GHz input signal. The Frequency Discriminator Method was used which had a delay line with the following characteristics: delay was 100 ns, attenuation was <10 dB and the cable used was RG-223.

Offset From Carrier (Hz)	dBc/Hz
1k	−80
10k	−106
100k	−131
1M	−144

1-12. ELECTRICAL EQUIPMENT AVAILABLE

The Carrier Noise Test Set has an HP-IB interface and can be used with any HP-IB compatible computing controller or computer for automatic systems applications.

1-13. RECOMMENDED TEST EQUIPMENT

Table 1-4 lists the test equipment recommended for use in testing, adjusting and servicing the Carrier Noise Test Set. The Critical Specification column describes the essential requirements for each piece of test equipment. Other equipment can be substituted if it meets or exceeds these critical specifications.

Table 1-4 also includes some alternate equipment listings. These alternate instruments are highlighted in Table 1-5 which also indicates the possible advantages of using them as substitutes.

The following information is supplied to aid the user when configuring the Carrier Noise Test Set in a system. The system specifications are for the HP 11729C and the HP 8662A.

Also given are the general requirements for an unknown RF source being used with the HP 11729C.

Table 1-3. System Specifications (1 of 2)

ABSOLUTE SYSTEM NOISE FLOOR

System noise is specified only when the HP 11729C is used with an HP 8662A Option 003[1].

Phase Detector Method (locking via EFC):

HP 11729C/8662A Absolute System Noise[2,3] (dBc/Hz):

Offset from Carrier (Hz)	Band 1 5 to 1280 MHz		Band 2 1.28 to 3.2 GHz		Band 3 3.2 to 5.76 GHz		Band 4 5.76 to 8.32 GHz	
	Typ.	Spec.	Typ.	Spec.	Typ.	Spec.	Typ.	Spec.
1	-58	-48	-53	-43	-47	-37	-43	-33
10	-88	-78	-83	-73	-77	-67	-73	-63
100	-108	-98	-103	-93	-97	-87	-93	-83
1k	-119	-115	-115	-110	-109	-104	-105	-100
10k	-130	-125	-129	-124	-127	-123	-125	-121
100k	-130	-126	-130	-126	-130	-126	-129	-125
1M	-140		-140		-138		-135	

Offset from Carrier (Hz)	Band 5 8.32 to 10.88 GHz		Band 6 10.88 to 13.44 GHz		Band 7 13.44 to 16.0 GHz		Band 8 16.0 to 18.0 GHz	
	Typ.	Spec.	Typ.	Spec.	Typ.	Spec.	Typ.	Spec.
1	-40	-30	-38	-28	-37	-27	-35	-25
10	-70	-60	-68	-58	-67	-57	-65	-55
100	-90	-80	-88	-78	-87	-77	-85	-75
1k	-102	-97	-100	-95	-99	-94	-97	-92
10k	-123	-119	-122	-118	-121	-116	-119	-115
100k	-129	-125	-128	-125	-127	-124	-127	-123
1M	-134		-132		-131		-129	

[1]The HP 8663A Option 003 (operated below 1280 MHz) may be used in place of the HP 8662A with no change in system performance.

[2]These system noise floor specifications apply for locking via the EFC of the HP 8662A crystal oscillator. Locking via the HP 8662A dc FM changes the phase noise on the tuna ble HP 8662A signal and therefore total system noise. Use the system phase noise equation at the end of footnote 3 to determine system phase noise when locking via the HP 8662A dc FM.

[3]The absolute system phase noise is dependent on the test signal frequency, therefore, the actual system noise may be lower than specified. Since the noise contribution of the HP 8662A front panel signal is a function of frequency selected, the overall system noise may improve for test frequencies <640 MHz from band centers. For example, for frequencies over the narrow range of 8.96 to 10.24 GHz, typical system phase noise at a 100 kHz offset is −134 dBc/Hz. To determine the system phase noise for any test frequency, see the system phase noise equation below.

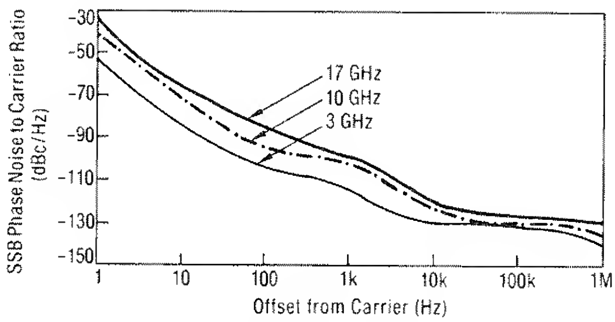
$$\mathcal{L}_{system} = 10 \log \left(N^2 \times 10^{\frac{\mathcal{L}_1}{10}} + 10^{\frac{\mathcal{L}_2}{10}} + 10^{\frac{\mathcal{L}_3}{10}} \right)$$

where N = center frequency of selected filter/640 MHz

$\mathcal{L}_1$ = absolute SSB phase noise of the 640 MHz reference signal (dBc/Hz)

$\mathcal{L}_2$ = absolute SSB phase noise of the 5 to 1280 MHz tunable signal (dBc/Hz)

$\mathcal{L}_3$ = residual noise of the HP 11729C (dBc/Hz)



Typical HP 11729C/8662A system noise (phase detector method, locking via EFC).

Frequency Discriminator Method:

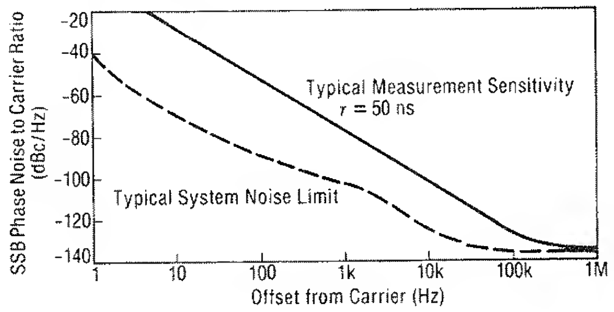
HP 11729C/8662A System Noise and Sensitivity: In the frequency discriminator mode, the lower limit of the measurement system sensitivity is set by the noise contribution of the 11729C/8662A. Typical system noise contribution of the HP 11729C/8662A is shown in the table below.

Offset from Carrier (Hz)	Typical System Noise (dBc/Hz) (frequency discriminator)		
	1.26 to 3.2 GHz	8.32 to 10.88 GHz	16.0 to 18.0 GHz
1	-54	-40	-35
10	-84	-70	-65
100	-104	-90	-85
1k	-116	-102	-97
10k	-139	-125	-120
100k	-149	-135	-130
1M	-149	-135	-130

The actual HP 11729C/8662A measurement sensitivity in the frequency discriminator method largely depends on the delay line (delay time) used. The longer the delay time, the closer the measurement sensitivity approaches the system noise limit. The graph shows the HP 11729C/8662A noise contribution, and a typically obtainable system sensitivity. A 34 foot section of flexible RF cable (RG 225) was used as the external time delay element τ = 50 ns.

Table 1-3. System Specifications (2 of 2)

Frequency Discriminator Method (cont'd)



Typical noise contribution of HP 11729C/8662A (frequency discriminator method) at X-band and typical system sensitivity using a 50 ns delay line discriminator.

Listed below are general requirements for the RF source when used with the HP 11729C in a system:

640 MHz signal source:

Frequency: 640 MHz ±50 ppm.
Level: +1 dBm minimum, +4 dBm maximum.
Frequency control: dependent on method of phase lock chosen.

5—1280 MHz tunable source:

Frequency: 5—1280 MHz.
Level: 0 dBm ±1 dB. Typically usable to ϵ10 dBm with change in loop bandwidth and system noise floor.

Frequency control: dependent on method of phase lock chosen; could require dc coupled frequency controlled input accepting ±1V or ±10V, with necessary deviation dependent on source under test.

Use the following procedure to calculate the Absolute System Noise Floor of the HP 11729C and an RF source other than the HP 8662A.

Absolute System Noise Floor (general case):

Measurement system noise floor is dependent on the RF reference source(s) used. For the frequency discriminator method, system noise is a composite of the noise on the multiplied 640 MHz signal plus the residual noise of the HP 11729C. For the phase detector method, system noise has the additional noise of the RF tunable source at the phase detector input. System noise can be described by

$$\mathcal{L}_{system} = 10 \log \left(N^2 \times 10^{\frac{\mathcal{L}_1}{10}} + 10^{\frac{\mathcal{L}_2}{10}} + 10^{\frac{\mathcal{L}_3}{10}} \right)$$

where N = center frequency of selected filter/640 MHz

$\mathcal{L}_1$ = absolute SSB phase noise of the 640 MHz reference signal (dBc/Hz)

$\mathcal{L}_2$ = absolute SSB phase noise of the 5 to 1280 MHz tunable signal (dBc/Hz)

$\mathcal{L}_3$ = residual noise of the HP 11729C (dBc/Hz)

Table 1-4. Recommended Test Equipment (1 of 3)

Instrument	Critical Specifications	Recommended Model	Use*
Amplifier	Input Frequency: 640 MHz Gain: 22 dB Noise Figure: < 10 dBm	HP 8447E/F	P
Attenuator	Input Frequency Range: 640 MHz to 1 GHz Incremental Attenuation: 1 dB steps Maximum attenuation: 10 dB	HP 355C	P
Cable (RF)	BNC(m) to BNC(m) (9 inches)	HP 10502A	P
Cable (RF)	BNC(m) to BNC(m) (24 inches)	HP 11170B	OPAT
Carrier Noise Test Set	(There isn't any substitute instrument for the Carrier Noise Test Set) Band Range: 8.32 GHz to 10.88 GHz IF output bandwidth: 400 MHz IF output level: +7 dBm Residual Phase Noise: (Using a 10 GHz Test Signal) **Offset From Carrier (Hz)** — **Level (dBc/Hz)** 10 — −90 100 — −105 1k — −115 10k — −127 100k — −137 1M — −137	HP 11729C[1]	P
Controller	Minimum controller capability as defined by IEEE Standard 488-1975 and the identical ANSI Standard MC1.1: SH1, AH1, T4, TE0, L2, LE0, SR0, RL1, PP0, DC0, DT0, and C1-4,26.	HP 85B	OA
Digital Multimeter	Input Range: 0 to 15 Vdc Accuracy: ±1 mVdc	HP 3468A	AT
Function Generator	Frequency: 1 kHz Function: sinewave Amplitude: 500 mVdc to 5 Vdc DC Offset Capability	HP 3312A	P
Isolator	Power Input level: +15 dBm Frequency Input: 10 GHz	HP 0955-0178[2]	P

*A = Adjustments; O = Operator's Checks; P = Performance Tests; T = Troubleshooting

[1]This Carrier Noise Test Set must contain a Band Range that is included in the Carrier Noise Test Set under test.

[2]Under certain conditions an attenuator can be used in place of the isolator. For more information see the AM Noise Floor Performance Test in Section IV.

Table 1-4. Recommended Test Equipment (2 of 3)

Instrument	Critical Specifications	Recommended Model	Use*
Low Frequency Spectrum Analyzer	Frequency Range: 0 Hz to 1 kHz Measurement Range: −75 dBm to 0 dBm Resolution Bandwidth: 30 MHz Video Averaging Video Readout Accuracy: ±0.5 dB	HP 3582A HP 3561A	P
Low Noise Oscillator	One Frequency between: 5 MHz and 18 GHz Amplitude: +10 dBm AM noise: **Offset From Carrier (Hz)** — **Level (dBc/Hz)** 100k — <−155 1M — <−160	MA 86651A[3] (M/A Com)	P
Microwave Synthesized Source	Frequency Range: 2 GHz to 10 GHz Amplitude: >+10 dBm Short term Frequency stability: 1 part in 10^7 External AM Modulation capability	HP 8340A HP 8673B	OPAT
Oscilloscope	Bandwidth: 100 Hz Vertical Sensitivity: 5 mV/div AC Coupled	HP 1740A	T
Power Meter	Accuracy: ±0.2 dBm	HP 436A	PA
Power Sensor	Frequency Range: 100 MHz to 10 GHz Power Range: 0 dBm to 15 dBm Input Impedance: 50Ω SWR: < 1.25	HP 8481A	PA
Power Splitter	Input Frequency Range: 400 MHz to 700 MHz Output tracking: <0.25 dB	HP 11667A	P
Power Splitter	Input Frequency: 10 GHz Output tracking: <0.25 dB	HP 11667A	P
Power Supply	Voltage Output: +10 Vdc maximum	HP 6214B	P
RF Spectrum Analyzer	Frequency Range: 1 kHz to 10 MHz Dynamic Range: −75 dBm to 0 dBm Resolution Bandwidth: 100 Hz and 100 kHz Video Filtering Marker capability Reference Level Control Video Readout Accuracy: ± 0.5 dB Sensitivity: −117 dB	HP 8566B	OPT

*A = Adjustments; O = Operator's Checks; P = Performance Tests; T = Troubleshooting

[3]Commercial Sources Division, M/A-COM, South Avenue, Burlington, MA 01803

Table 1-4. Recommended Test Equipment (3 of 3)

Instrument	Critical Specifications	Recommended Model	Use*
RF Synthesized Signal Generator	Auxillary 640 MHz Signal: Absolute Phase Noise: **Offset From Carrier (Hz)** / **Level (dBc/Hz)** 1 / − 54 10 / − 84 100 / −104 1 k / −121 10 k / −145 100 k / −157 1 M / −157 Level: >+1 dBm to <+4 dBm Electronic Frequency Control: ± 1 Vdc or ± 10 Vdc RF Output: Frequency Range: 300 MHz to 700 MHz Frequency resolution: 10 Hz Amplitude: −40 dBm to 0 dBm External AM Modulation capability	HP 8662A[4] (Opt. 003) HP 8663A[4] (Opt. 003)	OPAT
Termination	50 ohms BNC	HP 11593A	P
Waveguide	UG-135/U to N(f)	HP X281C	P

* A = Adjustments; O = Operator's Checks; P = Performance Tests; T = Troubleshooting

[4]For one HP 8662A or 8663A to operate with the Carrier Noise Test Set and give the best phase noise performance, two rear panel connectors are required. One connector must supply 640 MHz and the other connector must accept the Electronic Frequency Control signal from the Carrier Noise Test Set. As of April 1984 these two connectors are on the rear panel of each standard HP 8662A or 8663A. Before April 1984 these two connectors were specified by options H03 and H12. The HP 8662A or 8663A option 003 includes testing the phase noise of the 640 MHz signal.

Table 1-5. Recommended Alternate Test Equipment

Instrument Type	Suggested Alternate	Instrument Replaced	Advantages of Alternate
RF Synthesized Signal Generator	HP 8663A	HP 8662A	The HP 8663A is a direct substitute for the HP 8662A.
Microwave Synthesized Source	HP 8673B	HP 8340A	Less expensive
Low Frequency Spectrum Analyzer	HP 3561A	HP 3582A	Better Accuracy

SECTION II
INSTALLATION

2-1. INTRODUCTION

This section provides the information needed to install the Carrier Noise Test Set. Included is information pertinent to initial inspection, power requirememts, line voltage selection, power cables, interconnection, environmemt, instrument mounting, storage and shipment.

2-2. INITIAL INSPECTION

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, displays).

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1. Procedures for checking electrical performance are given in Section IV. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance test, notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

2-3. PREPARATION FOR USE

2-4. Power Requirements

The Carrier Noise Test Set requires a power source of 100, 120, 220 or 240 Vac, +5% to −10%, 48 to 66 Hz single phase. Power consumption is 75 VA maximum.

WARNINGS

This is a Safety Class I product (that is, provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals through the power cord or supplied power cord set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an external autotransformer, make sure the autotransformer's common terminal is connected to the neutral (that is, the grounded side of the mains supply).

⚠ 2-5. Line Voltage and Fuse Selection

CAUTION

BEFORE PLUGGING THIS INSTRUMENT into the mains (line) voltage, be sure the correct voltage and fuse have been selected.

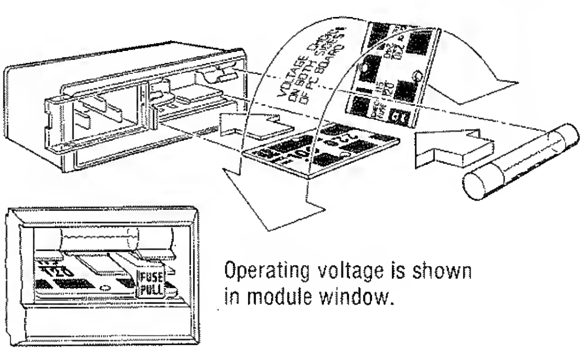
Verify that the line voltage selection card and the fuse are matched to the power source. Refer to Figure 2-1, Line Voltage and Fuse Selection.

Fuses may be ordered under HP part numbers 2110-0001, 1.0A (250V) for 100/120 Vac operation and 2110-0012, 0.5A (250V) for 220/240 Vac operation.

2-6. Power Cables

WARNING

BEFORE CONNECTING THIS INSTRUMENT, the protective earth terminal of this instrument must be connected to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding).



SELECTION OF OPERATING VOLTAGE

1. Open cover door, pull the FUSE PULL lever and rotate to left. Remove the fuse.
2. Remove the Line Voltage Selection Card. Position the card so the line voltage appears at top-left corner. Push the card firmly into the slot.
3. Rotate the FUSE PULL lever to its normal position. Insert a fuse of the correct value in the holder. Close the cover door.

WARNING

To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz (leakage currents at these line settings may exceed 3.5 mA).

Figure 2-1. Line Voltage and Fuse Selection

Power Cables (cont'd)

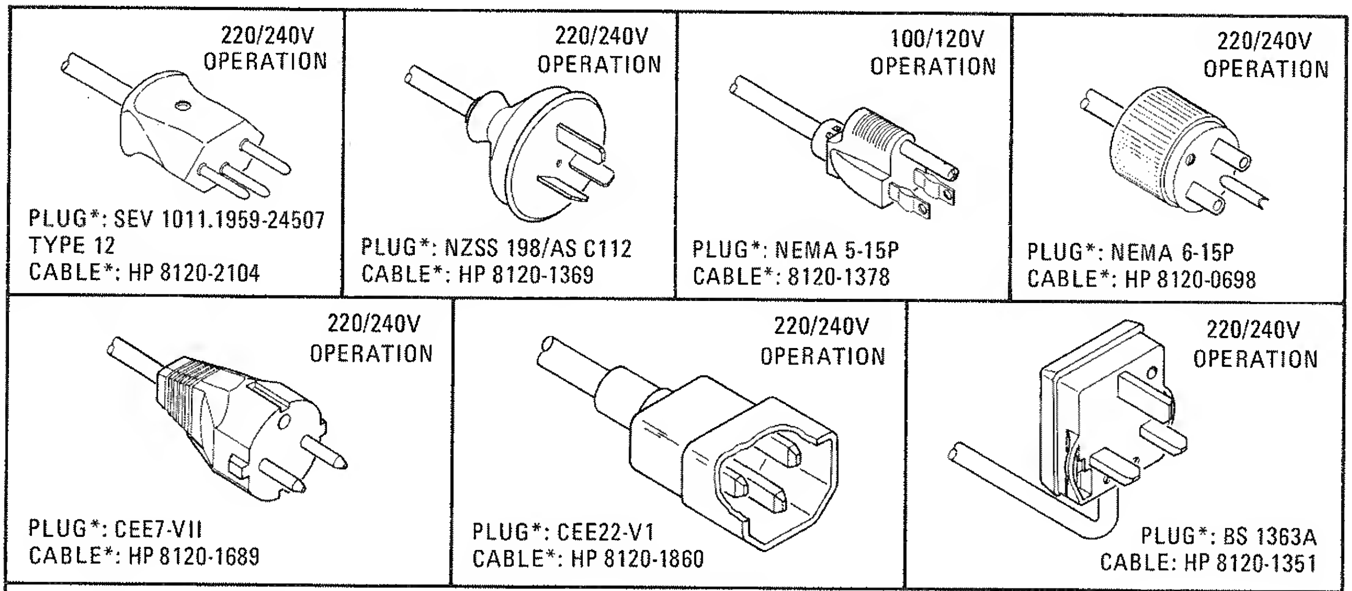
This instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The power cable plug shipped with each instrument depends on the country of destination. Refer to Figure 2-2 for the part numbers of power cables available.

2-7. HP-IB Address Selection HP-IB

The HP-IB address is switch-selectable through five miniature slide switches located on the rear panel of the Carrier Noise Test Set. These switches provide the means to select one of 31 valid HP-IB addresses (00 through 30). HP-IB addresses greater than 30 (decimal) are invalid. Refer to Table 2-1 for the allowable HP-IB address codes. Listed are the valid address switch settings and equivalent ASCII character and decimal value. When the instrument is shipped from the factory, the HP-IB address is preset to 06 (decimal). (In binary, this is 00110.) This preset address is shown shaded in Table 2-1.

The following procedure describes how to change the settings of the HP-IB address switches.

Use a small screwdriver to set the switches to the desired HP-IB address in binary. The five switches are labeled A1 through A5, where A1 is the least significant address bit and A5 is the most signifi-



*The number shown for the plug is the industry identifier for the plug only.
The number shown for the cable is an HP part number for a complete cable including the plug.

Figure 2-2. Power Cable and Mains Plug Part Numbers

Table 2-1. Allowable HP-IB Address Codes

Decimal Equivalent[1]	Listen Address Character	Talk Address Character	Address Switches[1] A5	A4	A3	A2	A1
0	SP	®	0	0	0	0	0
1	!	A	0	0	0	0	1
2	"	B	0	0	0	1	0
3	#	C	0	0	0	1	1
4	$	D	0	0	1	0	0
5	%	E	0	0	1	0	1
6	&	F	0	0	1	1	0 [2]
7	'	G	0	0	1	1	1
8	(	H	0	1	0	0	0
9	)	I	0	1	0	0	1
10	*	J	0	1	0	1	0
11	+	K	0	1	0	1	1
12	,	L	0	1	1	0	0
13	-	M	0	1	1	0	1
14	.	N	0	1	1	1	0
15	/	0	0	1	1	1	1
16	0	P	1	0	0	0	0
17	1	Q	1	0	0	0	1
18	2	R	1	0	0	1	0
19	3	S	1	0	0	1	1
20	4	T	1	0	1	0	0
21	5	U	1	0	1	0	1
22	6	V	1	0	1	1	0
23	7	W	1	0	1	1	1
24	8	X	1	1	0	0	0
25	9	Y	1	1	0	0	1
26	:	Z	1	1	0	1	0
27	;	[	1	1	0	1	1
28	<	\	1	1	1	0	0
29	=	]	1	1	1	0	1
30	>	0	1	1	1	1	0

[1]Decimal characters and the five address switches relate to the last five bits of both talk and listen addresses.

[2]Factory-set address.

HP-IB Address Selection (cont'd)

cant address bit. Sliding the switch downward (as viewed from the rear of the instrument) "sets" the corresponding address bit to "1" while sliding the switch upwards "clears" the bit (bit=0). Setting all of the address bits to "1" will result in an invalid HP-IB address (31 decimal). In this case an HP-IB address of 30 (decimal) will be stored in memory once the instrument is powered up.

If the HP-IB address is changed when the instrument is on the instrument will have to be turned off then turned on again. This is necessary so the new address can be read by the microprocessor and stored in memory.

Along with the five address switches (A1 through A5) there are two other switches. These two switches are labeled "LO" LISTEN ONLY and "TO" TALK ONLY. When either the "LO" or "TO" switch is set to "1" the Carrier Noise Test Set becomes either a TALKER ONLY or a LISTENER ONLY and the HP-IB address is overridden. At the factory the "LO" and "TO" switches are set to "0".

2-8. Interconnections

For the Carrier Noise Test Set to be fully operational it may have to be connected to an external RF source for one or both of the drive signals (5—1280 MHz and 640 MHz). The drive signals are essential to the operation of the Carrier Noise Test Set.

One of the drive signals can be supplied by the Carrier Noise Test Set. An internally generated 640 MHz reference signal can be provided by connecting the supplied cable-attenuator assembly between the proper rear panel connectors. For proper operation, it is essential that the supplied cable-attenuator assembly (HP 11729-60096 or HP 11729-60098 [Option 140]) be used to make the connection.

The following figures, in Section III OPERATION, show the interconnections to the Carrier Noise Test Set:

Figure 3-4 Phase Noise Measurement Setup (Phase Detector Method)

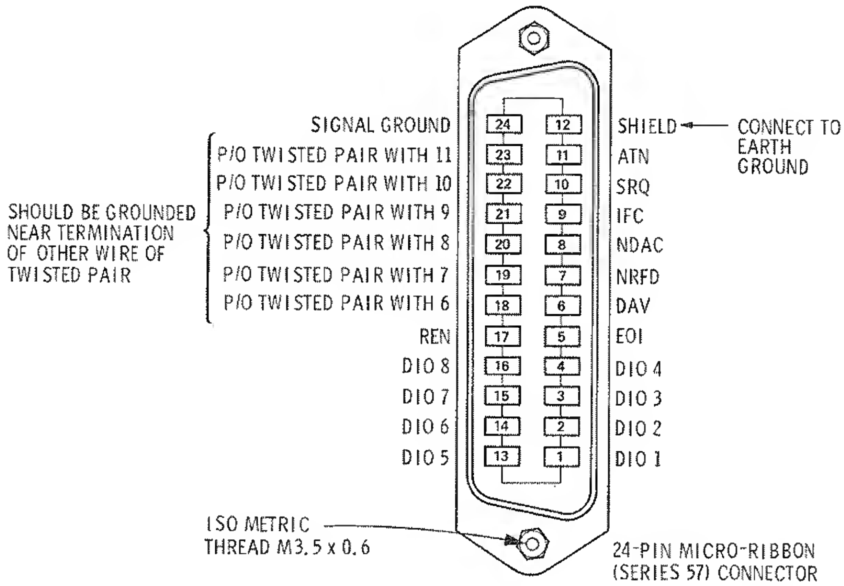
Figure 3-7 Phase Noise Measurement Setup (Frequency Discriminator Method)

Figure 3-8 AM Noise Measurement Setup

Interconnection data for the Hewlett-Packard Interface Bus is provided in Figure 2-3.

2-9. Mating Connectors

HP-IB Interface Connector. The HP-IB mating connector is shown in Figure 2-3. Note that the two securing screws are metric.



Logic Levels

The Hewlett-Packard Interface Bus Logic Levels are TTL compatible, i.e., the true (1) state is 0.0 Vdc to +0.4 Vdc and the false (0) state is +2.5 Vdc to +5.0 Vdc.

Programming and Output Data Format

Refer to Section III, Operation.

Mating Connector

HP 1251-0293; Amphenol 57-30240.

Mating Cables Available

HP 10833A, 1 metre (3.3 ft), HP 10833B, 2 metres (6.6 ft)
HP 10833C, 4 metres (13.2 ft), HP 10833D, 0.5 metres (1.6 ft)

Cabling Restrictions

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6.6 ft) of connecting cable per instrument.

2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20.0 metres (65.5 ft).

Figure 2-3. Hewlett-Packard Interface Bus Connection

Mating Connectors (cont'd)

Coaxial Connectors. Coaxial mating connectors used with the Carrier Noise Test Set should be 50 ohm Type N and 50 ohm BNC male connectors.

2-10. Operating Environment

The operating environment should be within the following limitations:

Temperature .... 0 to +55C
Humidity .... .5% to 95% relative at 40°C
Altitude .... <4600 metres (15 000 feet)

2-11. Bench Operation

The instrument cabinet has plastic feet and fold-away tilt stands for convenience in bench operation. (The plastic feet are shaped to ensure self-alignment of instruments when they are stacked.) The tilt stands raise the front of the Carrier Noise Test Set for easier viewing of the front panel.

2-12. Rack Mounting

WARNING

The Carrier Noise Test Set weighs 10.4 kg (23 lb.), therefore care must be exercised when lifting to avoid personal injury. Use equipment slides when rack mounting.

Rack mounting information is provided with the rack mounting kits. If the kits were not ordered with the instrument as options, they may be ordered through the nearest Hewlett-Packard office. Refer to the paragraph entitled Mechanical Options in Section I.

2-13. STORAGE AND SHIPMENT

2-14. Environment

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment:

Temperature .... −55°C to +75°C
Humidity .... <95% relative at 40°C
Altitude .... 15 300 metres (50 000 feet)

2-15. Packaging

Tagging for Service. If the instrument is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the back of this manual and attach it to the instrument.

Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. Mark the container "FRAGILE" to assure careful handling. In any correspondence refer to the instrument by model number and full serial number.

Other Packaging. The following general instructions should be used for re-packaging with commercially available materials:

a. Wrap the instrument in heavy paper or plastic. (If shipping to a Hewlett-Packard office or service center, complete one of the blue tags mentioned above and attach it to the instrument.)

b. Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 psi) test material is adequate.

c. Use enough shock-absorbing material (75 to 100 mm layer; 3 to 4 inches) around all sides of the instrument to provide firm cushion and prevent movement in the container. Protect the front panel with an appropriate type of cushioning material to prevent damage during shipment.

d. Seal the shipping container securely.

e. Mark the shipping container "FRAGILE" to assure careful handling.

SECTION III
OPERATION

3-1. INTRODUCTION

This section provides complete operating information for the Carrier Noise Test Set. Included are general operation instructions; detailed descriptions of each front and rear panel key, connector, switch and annunciator; information on remote operation; operator's checks; and operator's maintenance procedures.

3-2. Local Operation

Information covering local operation of the Carrier Noise Test Set is given in two places, namely detailed panel features and general operating instructions.

Detailed Panel Features. Figure 3-1 and Figure 3-2 illustrate the front and rear panels of the Carrier Noise Test Set and provide descriptions of each key, connector, switch and annunciator.

General Operating Instructions. Under general operating structions the following topics are covered:

- Power-on sequences
- Power-on procedure
- Phase noise measurement using the Phase Detector Method
- Phase noise measurement using the Frequency Discriminator Method
- AM noise measurement

3-3. Remote Operation (HP-IB) HP-IB

The Carrier Noise Test Set is capable of remote operation via the Hewlett-Packard Interface Bus. Knowledge of local operation is essential for HP-IB programming since most of the data messages contain the same keystroke-like sequences. HP-IB information is presented in the following areas of this section:

- A summary of HP-IB capabilities is provided in Table 3-3.
- A summary of program codes is provided in Table 3-4.

3-4. Operator's Checks

Operator's checks are simple procedures designed to verify that the main functions of the Carrier Noise Test Set operate properly.

These procedures require a microwave synthesized source, an RF synthesized signal generator, a spectrum analyzer, a controller (for HP-IB checks) and interconnecting cables.

3-5. Operator's Maintenance

WARNING

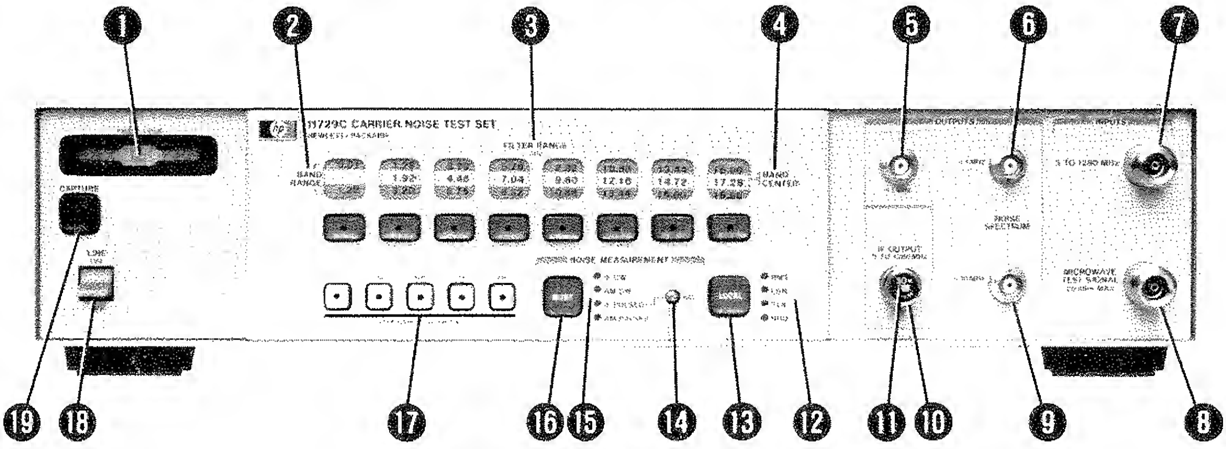
For continued protection against fire hazard, replace the line fuse with a 250 V fuse of the same rating only. Do not use repaired fuses or short-circuited fuseholders.

The only maintenance that the operator should normally perform is the replacement of the primary power fuse. All other maintenance should be referred to qualified service personnel.

The primary power fuse is located within the Line Power Module. Refer to Figure 2-1 for instructions on how to change the fuse.

If the instrument does not operate properly and is being returned to Hewlett-Packard for service, please complete one of the blue tags located at the end of this manual and attach it to the instrument. Refer to Section II for packaging instructions.

FRONT PANEL FEATURES



1. **PHASE LOCK INDICATOR.** The primary purpose of the PHASE LOCK INDICATOR is to show when the device under test and the tunable 5—1280 MHz source are in phase quadrature (that is, 90 degrees out of phase). When the device under test and the tunable 5—1280 MHz source are in phase quadrature a green LED will be illuminated in the center of the PHASE LOCK INDICATOR. When the two sources are greater than 100 kHz apart a red LED will be illuminated to the left or right of the green LED. As the frequency difference decreases all the LEDs will light up dimly. Finally, as the two sources approach quadrature the LEDs will fully light one at a time, from left to right. When the center green LED is illuminated the two sources are in phase quadrature.

2. **BAND RANGE.** BAND RANGE describes the range of microwave test signals that can be input for each of the buttons below FILTER RANGE. The BAND RANGE chosen must contain the microwave test signal. The BAND RANGE desired is enabled by pressing the button below that BAND RANGE.

3. **FILTER RANGE.** FILTER RANGE describes the range of microwave test signals that can be accepted by the Carrier Noise Test Set (0.010—18 GHz).

4. **BAND CENTER.** The broad range of microwave test signals is possible because of a 640 MHz comb generator in the Carrier Noise Test Set. Through a series of filters certain harmonics from the comb generator are passed. The BAND CENTER frequency of the BAND RANGE chosen is the only harmonic (combline) from the comb generator that is passed. The filter used for selecting the harmonic is a 200 MHz passband filter centered around the combline.

5. **AUX NOISE.** This is a female BNC connector with an output impedance of 600Ω. The signal output is a dc level that is proportional to the phase difference between the microwave test signal and the tunable 5—1280 MHz signal. The dc level has ac fluctuations directly proportional to the phase noise of the microwave test signal, if the phase noise of the 640 MHz signal and the tunable 5—1280 MHz signal is less than the microwave test signal. The output and an oscilloscope can be used as an external quadrature monitor, because of the direct proportionality of the dc level to the phase difference of the microwave test signal and the tunable 5—1280 MHz signal.

6. **NOISE SPECTRUM < 1 MHz OUTPUT.** This is a female BNC connector with an output impedance of 600Ω. This output is useful for measuring the phase noise of the device under test at offsets from the carrier of dc to 1 MHz.

   The signal output is a dc level directly proportional to the phase difference between the microwave test signal and the tunable 5—1280 MHz signal. The dc level has ac fluctuations that are directly proportional to the phase noise of the the microwave test signal, if the phase noise of the 640 MHz signal and 5—1280 MHz signal is less than the microwave test signal.

Figure 3-1. Front Panel Features (1 of 3)

FRONT PANEL FEATURES

NOTE

The bandwidth (dc to 1 MHz) is not completely flat. The 3 db points are at dc and 1.5 MHz.

7. **5 to 1280 MHz INPUT.** This is a female type-N connector with a 50Ω input impedance. The frequency of the input signal is 5—1280 MHz from a tunable source. The frequency of the signal input is set to equal the microwave test signal minus the BAND CENTER frequency of the BAND RANGE chosen. The input level should be 0 dBm ±1 dBm. The user sets this signal in phase quadrature (that is, 90 degrees out of phase) with the microwave test signal. The IF OUTPUT is connected to this input, through a delay line, for the Frequency Discriminator Method of making a phase noise measurement.

8. **MICROWAVE TEST SIGNAL INPUT.** This is a female type-N connector with a 50Ω input impedance. This connector is used to connect the microwave test signal to the Carrier Noise Test Set. The input frequency range is 10 MHz to 18 GHz. The input level should be as follows:

   For test frequencies >1.28 GHz: +7 dBm to +20 dBm (Typically usable down to −15 dBm with potential noise floor degradation). The optimal level is +7 dBm to +20 dBm.

   For test frequencies <1.28 GHz: −5 dBm to +10 dBm (Typically usable down to −15 dBm with potential noise floor degradation. The optimal level is from −2 dBm to +3 dBm.)

9. **NOISE SPECTRUM < 10 MHz OUTPUT.** This is a female BNC connector with an output impedance of 50Ω and 40 dB of gain over the <1 MHz OUTPUT. This output is useful for measuring the phase noise or amplitude (AM) noise of the device under test at offsets from the carrier of 10 Hz to 10 MHz.

   The signal output is a dc level that is directly proportional to the phase difference between the microwave test signal and the tunable 5—1280 MHz signal. The dc level has ac fluctuations that are directly proportional to the phase noise of the microwave test signal, if the phase noise of the 640 MHz signal and the tunable 5—1280 MHz signal is less than the microwave test signal.

NOTE

The bandwidth (10 Hz to 10 MHz) is not completely flat. The 3 dB points are at 10 Hz and 15 MHz.

10. **IF OUTPUT 5—1280 MHz.** This is a female BNC connector with an output impedance of 50Ω. The output frequency will be 5 to 1280 MHz. The exact frequency is the intermediate difference frequency (IF) from the mixing of the microwave test signal and the BAND CENTER frequency of the BAND RANGE chosen. The output level is +7 dBm minimum.

11. **50 OHM TERMINATION.** With the 50Ω termination connected to the IF OUTPUT the Carrier Noise Test Set meets the requirements of MIL-STD 461 RE02. The IF OUTPUT is fully useable, just replace the 50 Ohm termination when the IF OUTPUT is not being used.

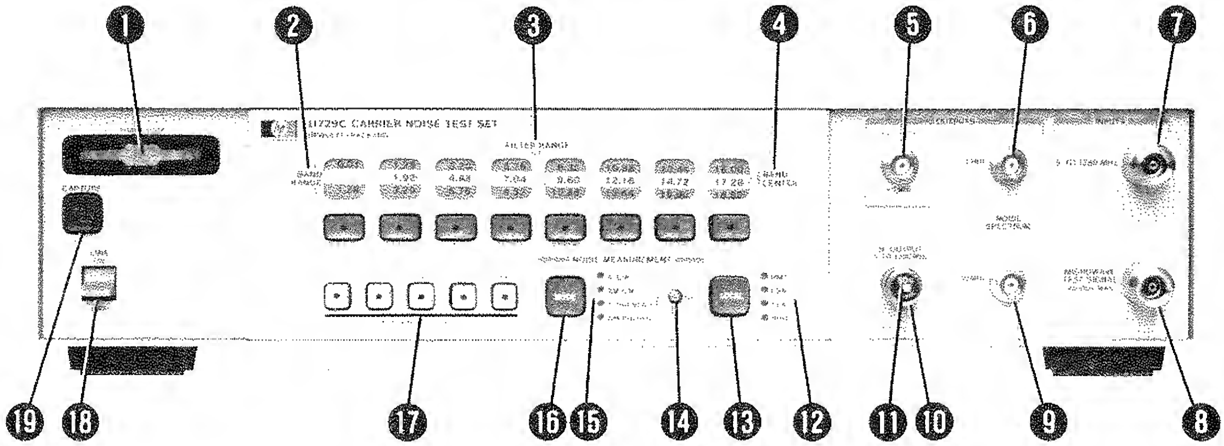
12. **HP-IB ANNUNCIATORS.** Display the HP-IB status. The REMOTE (RMT) annunciator lights when the Carrier Noise Test Set is in the remote mode. The TALK (TLK) annunciator lights when the Carrier Noise Test Set is addressed to talk. The LISTEN (LSN) annunciator lights when the Carrier Noise Test Set is addressed to listen. The SRQ annunciator lights when the Carrier Noise Test Set is sending a Require Service message to the controller.

13. **LOCAL.** Returns the Carrier Noise Test Set to local operation (front panel control) from remote HP-IB control provided that the instrument is not in Local Lockout.

14. **BAL.** This adjustment is used when making a measurement on a pulsed signal. This adjustment with the aid of an oscilloscope connected to the AUX NOISE connector on the front panel, is used to eliminate the dc offset in the phase lock loop.

Figure 3-1. Front Panel Features (2 of 3)

FRONT PANEL FEATURES



15. **MEASUREMENT ANNUNCIATORS.** When a continuous wave (CW) phase noise measurement is selected the ϕ, CW annunciator will be illuminated. When a continuous wave (CW) AM noise measurement is selected the AM, CW annunciator will be illuminated. When a pulsed phase noise measurement is selected the ϕ, PULSED annunciator will be illuminated. When a pulsed AM noise measurement is selected the AM, PULSED annunciator will be illuminated.

16. **MODE.** Used to select either a phase noise (CW or pulsed) or AM noise (CW or pulsed) measurement. AM noise is only installed with Option 130.

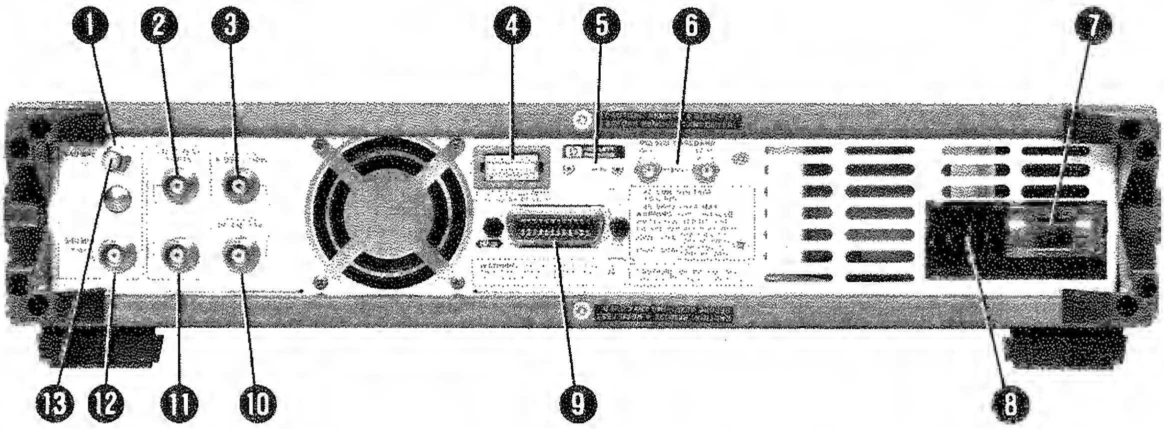
17. **LOCK BANDWIDTH FACTOR.** These five switches partially control the bandwidth of the phase lock loop, by setting the gain for a number of operational amplifiers in the Carrier Noise Test Set. Another factor in determing the loop andwidth is the frequency of the microwave test signal or the FM deviation set on the device under test or the tunable 5—1280 MHz source.

18. **LINE SWITCH.** Applies ac power to the Carrier Noise Test Set when set to the ON position.

19. **CAPTURE.** When CAPTURE is pressed the phase lock loop is changed from a second order loop to a first order loop. The phase lock loop consists of a voltage controlled oscillator (the tunable 5—1280 MHz source or the device under test), a phase detector and loop filter. The phase detector and loop filter are in the Carrier Noise Test Set. By changing to a first order loop the bandwidth of the loop is widened. By widening the loop bandwidth, acquiring phase quadrature is made easier. When CAPTURE is pressed the LOCK BANDWIDTH FACTOR buttons are overridden.

Figure 3-1. Front Panel Features (3 of 3)

REAR PANEL FEATURES



1. **640 MHz OUT.** This is a female SMA connector with an output impedance of 50 Ohms. The output frequency is 640 MHz. The output level is 11-13 dBm. This output is used to generate an internal 640 MHz signal when connected to the 640 MHz IN connector. When this output is not in use it must be terminated with the 50 Ohm termination that was shipped with the Carrier Noise Test Set.

2. **LOOP TEST PORT IN.** If a phase noise measurement is made within the phase lock loop bandwidth some of the phase noise will be suppressed. The LOOP TEST PORT IN connector lets the user input a signal to determine the transfer characteristic of the phase lock loop. Once the transfer characteristic is known the amount of noise suppression at any offset within the loop bandwidth can be determined. The amount of phase noise suppression is then used to correct the measured phase noise level.

   This is a dc coupled female BNC connector with a nominal input impedance of 10kΩ. The signal input should be from a random noise source, a tracking generator or a variable frequency sine wave source. The input level is typically less than 0.1 volts peak. The typical bandwidth is dc to 100 kHz.

3. **FREQ-CONT X-OSC.** This output is to be connected to the frequency control input of the tunable 5—1280 MHz source or the device under test (whichever is being used as the loop VCO) if the loop VCO requires ±10 volts dc for tuning. When so connected the loop VCO will change frequency to maintain phase quadrature between the device under test and the tunable 5—1280 MHz source.

   This is a female BNC connector with an output impedance of 100Ω. The output level is nominal from −10 volts dc to +10 volts dc.

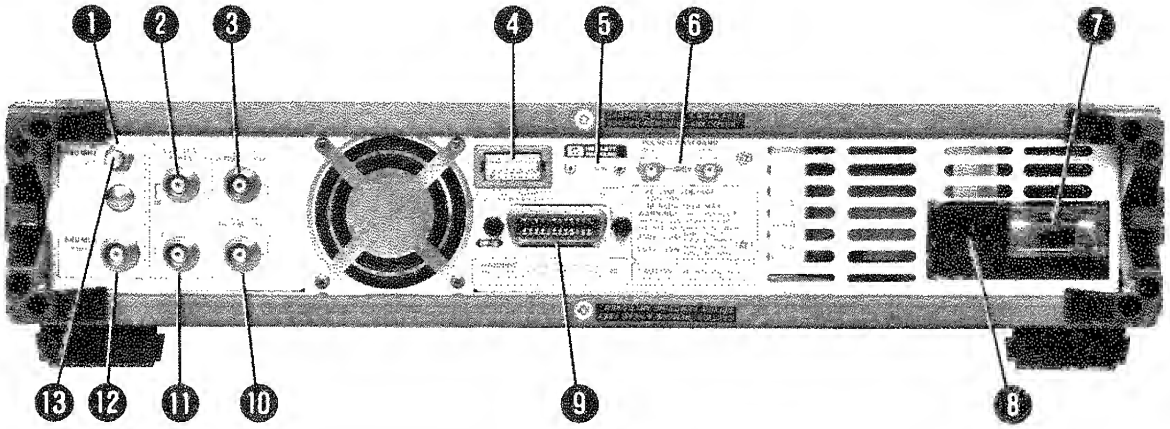
4. **HP-IB ADDRESS SWITCH.** Used to select one of 31 valid HP-IB addresses (00 through 30). The address is set in binary with A5 as the most significant bit and A1 as the least significant. To set a bit, "bit=", slide the switch down. To clear a bit, "bit=0", slide the switch up. By setting TALK ONLY "TO" or LISTEN ONLY "LO" TO "1" the HP-IB address is overriden. When the address is changed the Carrier Noise Test Set must be turned off then back on. This is necessary so the microprocessor will be aware of the address change.

5. **SERIAL NUMBER PLATE.** First four digits and letter constitute the prefix which defines the instrument configuration. The last five digits form a sequential suffix that is unique to each instrument. The plate also indicates any options supplied with the instrument.

6. **PULSED BASEBAND.** These connectors are used when making a pulsed measurement. The

Figure 3-2. Rear Panel Features (1 of 2)

REAR PANEL FEATURES



user connects a filter between the input and output to filter the pulse repetition frequency off the carrier. The filter chosen is dependent on the pulse repetition frequency of the carrier. The design of the filter must be such that the pulse repetition frequency and its multiples are terminated into 50 Ohms.

7. **FUSE.** Ordering information is presented in Section II, Installation.

8. **LINE POWER MODULE.** Permits operation from 100,120,220, or 240 Vac. The number visible in the window indicates nominal line voltage to which the instrument must be connected (see Figure 2-1). Center conductor is connected to the chassis for earth grounding.

9. **HP-IB CONNECTOR.** 24-pin female connector used to connect the Carrier Noise Test Set to the Hewlett-Packard Interface Bus (HP-IB) for remote operation. Connection information is presented in Section II, Installation.

10. **FREQ-CONT DC-FM.** This output is to be connected to the frequency control input of the tunable 5—1280 MHz source or the device under test (whichever is being used as the loop VCO) if the loop VCO requires ±1 volt dc for tuning. When so connected the loop VCO will change frequency to maintain phase quadrature between the device under test and the tunable 5—1280 MHz source.

    This is a female BNC connector with a nominal output impedance of 50Ω. The output level is nominal from −1 volt dc to +1 volt dc.

11. **LOOP TEST PORT OUT.** Once a signal has been input at the LOOP TEST PORT IN connector, this output is connected to a spectrum analyzer for displaying the phase lock loop transfer characteristic.

    This is a dc coupled female BNC connector with a nominal output impedance of 1 kΩ. The gain outside the phase lock loop bandwidth is equal to one.

12. **640 MHz INPUT.** This is a female BNC connector with a 50 Ohm input impedance. The input frequency must be 640 MHz ±32kHz. The input level must be +1 dBm to +4 dBm.

13. **50 Ohm TERMINATION.** For proper operation of an amplifier inside the Carrier Noise Test Set this termination must be connected to the 640 MHz OUT connector. The 640 MHz OUT connector is fully usable, just replace the 50 Ohm termination when the 640 MHz OUT connector is not being used.

Figure 3-2. Rear Panel Features (2 of 2)

OPERATOR'S CHECKS

3-6. OPERATOR'S CHECKS

Description Use the test set-up shown below to verify the front panel controlled functions are being executed by the microprocessor.

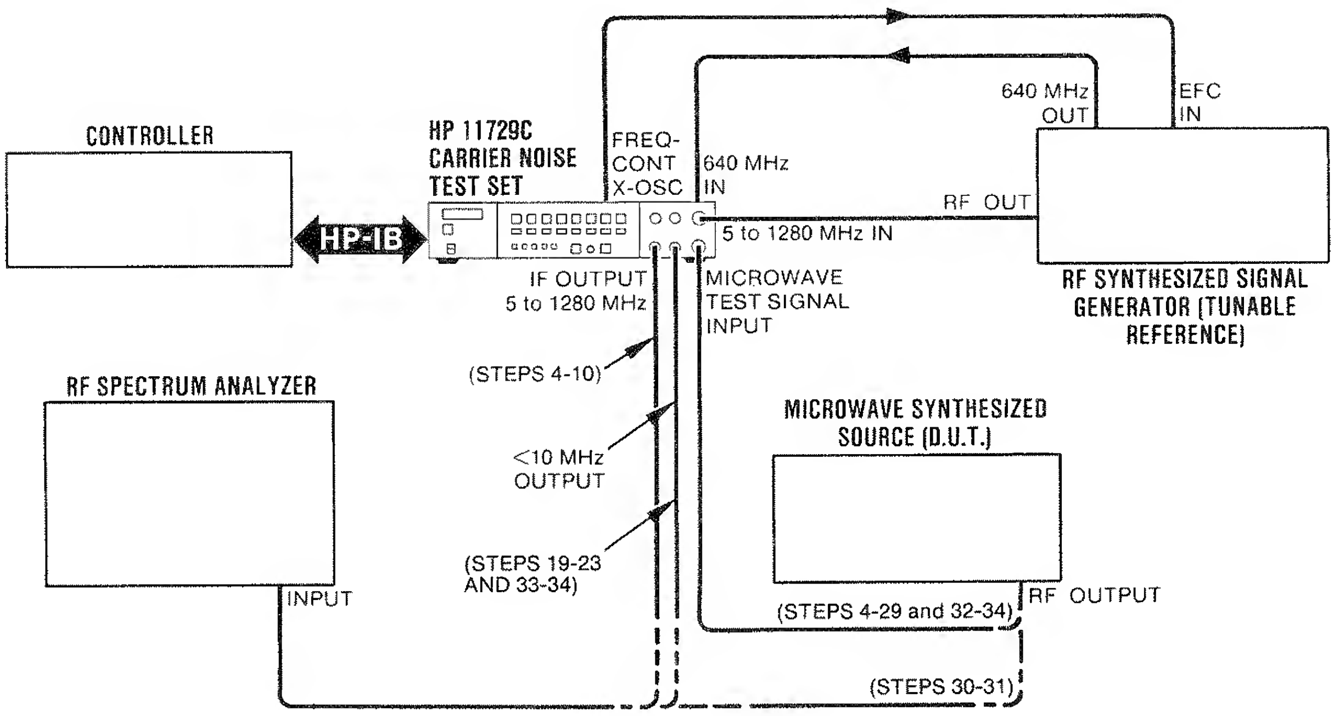


Figure 3-3. Basic Functional Checks Test Setup

Equipment

RF Synthesized Signal Generator (tunable reference)	HP 8662A (Option 003)
Microwave Synthesized Source (D.U.T.)	HP 8340A
Computer Controller	HP 85B
RF Spectrum Analyzer	HP 8566B

Procedure

Microprocessor Checks

1. Turn on and warm up all instruments for 30 minutes before proceeding.

2. Switch the Carrier Noise Test Set to ON and observe the front panel annunciators. An internal memory check of ROM and RAM is initiated when the Carrier Noise Test Set is switched on. If the memory system is working properly, all front panel annunciators will light for approximately 1.5 seconds. This also provides a quick visual inspection of each front panel annunciator.

   If memory failure is detected, no front panel annunciators will light during the 1.5 second time period.

3-6. OPERATOR'S CHECKS (cont'd)

Procedure (cont'd)

3. Press the FILTER RANGE buttons and MEASUREMENT MODE button. The clicking sound verifies the switching control of the microprocessor and the switch operation.

IF OUTPUT Check (Using an external source to supply the 640 MHz signal)

4. Set the D.U.T. as follows:

   Frequency .... 2.32 GHz
   Amplitude .... +10 dBm

5. Set the Carrier Noise Test Set as follows:

   Band center .... 1.92 GHz
   Measurement Mode .... ϕ, CW

6. Adjust the spectrum analyzer to display the 400 MHz IF OUTPUT (D.U.T. frequency minus BAND CENTER frequency).

NOTE

Present at the IF OUTPUT will be the IF signal (signal under test minus the BAND CENTER frequency of the BAND RANGE chosen), IF harmonics and spurious signals. Any IF harmonics or spurious signals can be disregarded. The signal with the highest amplitude is the desired signal.

The harmonics of the IF signal do not affect the phase noise measurement since the NOISE SPECTRUM OUTPUTS are filtered. The spurious signals may appear as sidebands on the IF signal and as spurs at the NOISE SPECTRUM OUTPUTS.

7. Check that the IF OUTPUT level is above the specified limit of +7 dBm minimum. Record the actual value of the IF OUTPUT frequency and level in Table 3-1.

8. If the IF OUTPUT frequency and level did not measure within specified limits check the frequency and power level of the 640 MHz IN signal and the microwave test signal. If a problem still exists refer to the troubleshooting on Service Sheet 1.

9. Change the frequency of the D.U.T to the next microwave test signal frequency listed in Table 3-1. Change the BAND RANGE on the front panel to the next BAND CENTER listed in Table 3-1.

10. Measure the IF OUTPUT frequency and level with the spectrum analyzer. Record the values and repeat the measurement for each of the BAND CENTER frequencies listed.

IF OUTPUT Check (Using the 640 MHz oscillator in the Carrier Noise Test Set)

11. Leave the settings on the D.U.T. and Carrier Noise Test Set to those that were used for the last measurement in step 10.

OPERATOR'S CHECKS (cont'd)

Procedure (cont'd)

12. Disconnect the cable to the 640 MHz IN connector, on the rear panel of the Carrier Noise Test Set.

13. Disconnect the SMA termination from the 640 MHz OUT connector, on the rear panel of the Carrier Noise Test Set.

14. Connect the 640 MHz OUT connector to the 640 MHz IN connector using the cable-attenuator assembly (HP 11729-60096 or HP 11729-60098 [Option 140]) that was shipped with the Carrier Noise Test Set.

NOTE

It is essential that the cable-attenuator assembly that was shipped with the Carrier Nosie Test Set be used to make the connection.

15. Measure the IF OUTPUT frequency and level with the spectrum analyzer. Verify that the typical frequency measured is 400 MHz and the level is greater than +7 dBm.

16. Disconnect the cable between the 640 MHz OUT and 640 MHz IN connectors.

17. Reconnect the 50 Ohm SMA termination to the 640 MHz OUT connector.

18. Reconnect the 640 MHz signal from the tunable reference to the 640 MHz IN connector on the Carrier Noise Test Set.

Table 3-1. IF Output Check

Microwave Test Signal (GHz)	Band Center (GHz)	IF Output Frequency (MHz)		IF Output Level (dBm)	
		Actual	Typical	Minimum	Actual
2.32	1.92	______	400	+7	______
4.88	4.48	______	400	+7	______
7.44	7.04	______	400	+7	______
10.00	9.60	______	400	+7	______
12.56	12.16	______	400	+7	______
15.12	14.72	______	400	+7	______
17.68	17.28	______	400	+7	______

Phase Lock Check

19. Connect the <10 MHz OUTPUT from the Carrier Noise Test Set to the RF spectrum analyzer.

20. Set the Carrier Noise Test Set as follows:

    Lock Bandwidth Factor 100
    Measurement Mode .... ϕ, CW
    Band Range .... 8.32 to 10.88 GHz

OPERATOR'S CHECKS

OPERATOR'S CHECKS (cont'd)

Procedure (cont'd)

NOTE

If this filter is not included in the Carrier Noise Test Set, select an available BAND RANGE.

21. Set the D.U.T. as follows:

    Frequency .... 10 GHz
    Amplitude .... +10 dBm

NOTE

The test signal is tuned 400 MHz above the center frequency of the BAND RANGE selected on the Carrier Noise Test Set

22. Set the tunable reference as follows:

    Frequency .... 400 MHz
    Amplitude .... 0 dBm

23. Press and release CAPTURE, on the Carrier Noise Test Set, to phase lock the D.U.T. to the tunable reference.

    If the sources do not phase lock (green bar does not remain illuminated on the front panel phase lock indicator) the tunable reference must be tuned closer in frequency to the IF frequency ($f_{IF} = f_{D.U.T.} - f_{band\ center\ frequency}$). Press CAPTURE while tuning the tunable reference in 1 kHz steps. Watch the phase lock indicator on the Carrier Noise Test Set. When the LED's on the indicator all light up, reduce the resolution of the tunable reference by a factor of 10.

NOTE

Connect the spectrum analyzer to the <10 MHz OUTPUT, on the Carrier Noise Test Set, if difficulties occur in determining the direction to tune the tunable reference to acquire phase lock.

The signals displayed on the spectrum analyzer represent the frequency difference between the two inputs to an internal mixer/phase detector in the Carrier Noise Test Set. The signals will decrease in frequency to dc when tuning towards phase lock and increase in frequency when tuning away from phase lock.

Press CAPTURE and tune in this reduced resolution. Watch the red LEDS on the Carrier Noise Test Set phase lock indicator step through one side of the display - to the green bar - then to the other side of the display. Again reduce the resolution on the tunable reference by a factor of 10. Tune in this finer resolution until the green LED is illuminated. When the green LED is illuminated release CAPTURE.

Display Deviation Check

24. If the Carrier Noise Test Set is not phase locked perform the phase lock check (steps 19-23).

25. Hold CAPTURE in and increase the tunable reference in 10 Hz steps until the loop becomes unlocked. Watch the phase lock indicator, the red LEDs should fully light

OPERATOR'S CHECKS (cont'd)

Procedure (cont'd)

one at a time and move to the right. When the last LED is illuminated and you tune further the entire indicator should dimly light.

With CAPTURE pressed decrease the tunable reference in 10 Hz steps. The dimly illuminated indicator should change back to the red LEDs one at a time fully illuminated and moving to the left. When the last LED on the left is illuminated and you tune further, the entire indicator will dimly light.

26. When the last LED on the left or right lights and the tunable reference is increased or decreased further, the indicator should immediately dimly light. If the indicator goes blank perform the phase lock indicator adjustments in Section V.

AM Mode Check

NOTE

Perform this check only when the AM Noise Option is installed.

27. Set the Carrier Noise Test Set as follows:

    Measurement Mode .... AM, CW
    All other functions .... Not used

28. Set the D.U.T. as follows:

    Frequency .... 1 GHz
    Amplitude .... +10 dBm

29. AM modulate the microwave test signal at a 1 kHz rate.

30. Adjust the spectrum analyzer to view the 1 GHz signal and the 1 kHz AM sidebands.

31. Adjust the percent of AM modulation so that the 1 kHz AM sidebands are 40 dB below the 1 GHz carrier. (approximately a 2% depth)

32. Disconnect the microwave test signal from the spectrum analyzer. Connect the microwave test signal to the MICROWAVE TEST SIGNAL INPUT on the Carrier Noise Test Set.

33. Connect the <10 MHz OUTPUT, on the Carrier Noise Test Set, to the spectrum analyzer.

34. Adjust the spectrum analyzer to view the 1 kHz detected signal. AM MODE is operating if the 1 kHz signal level is −7 dBm ±3 dBm.

HP-IB Address Verification

35. Press and hold the front panel LOCAL key. The LED's on the BAND RANGE select buttons will display the current address in binary.

36. Check the address switch setting on the rear panel of the Carrier Noise Test Set to verify the display on the BAND RANGE select buttons is correct.

OPERATOR'S CHECKS (cont'd)

Procedure (cont'd)

Local/Remote Operation Check

37. Set the Carrier Noise Test Set to remote using the following:

Remote 706

38. Press any front panel key except LOCAL to verify that the front panel keys are disabled.

39. Press the LOCAL key. This switches the instrument out of the remote mode.

NOTE

When the local key is pressed the REMOTE annunciator will turn off, but the LISTEN annunciator will stay illuminated.

Now press any front panel key to verify the front panel keys are enabled.

Status Byte Check

40. Enter Program 1 into the computer. Insert the correct select code and HP-IB address, for your Carrier Noise Test Set, into the SPOLL function. The HP-IB address of the Carrier Noise Test Set is factory preset to 06. The user can select the HP-IB address by changing the position of the HP-IB address switches on the rear panel of the Carrier Noise Test Set. (Refer to Section II paragraph 2-7, HP-IB Address Selection, for further information.)

PROGRAM 1

```
10 A = SPOLL(###)     (### = Current Carrier Noise Test Set select code
20 DISP A             and address.)
30 GOTO 10            Example: 706
                                7 = Select code
                                06 = Address
```

This program monitors the status byte of the Carrier Noise Test Set and displays the equivalent decimal value on the computer. The status of the phase lock detector sent out over HP-IB should agree with the phase lock indicator on the front panel. Table 3-2 defines the status bits and their decimal equivalents for the two phase lock conditions.

Table 3-2. Status Bits and Their Decimal Equivalents for Two Phase Lock Conditions

Phase Condition	Status Bits-Binary								Computer Output*
	DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1	
unlocked	0	0	0	0	0	1	0	0	4
locked (green Bar)	0	0	0	0	0	0	1	0	2

*If no other bits are logical one.

OPERATOR'S CHECKS (cont')

Procedure (cont'd)

41. Set the Carrier Noise Test Set to the phase lock condition (green LED is illuminated on the front panel phase lock display). For help use the phase lock check (steps 19-23).

42. Run Program 1 and compare the number displayed on the computer to the phase condition of the phase lock indicator on the Carrier Noise Test Set. The computer displays a decimal 2 when in the phase lock condition.

43. Increase the frequency of the tunable reference by 1 MHz. Verify that the unlocked condition (red LED adjacent to the left of the green LED) is detected by the microprocessor. A decimal 4 should be displayed on the computer.

    If the number (2 or 4) displayed on the computer does not correspond to the phase lock condition, displayed on the front panel phase lock indicator, perform the phase lock indicator adjustment procedures in Section V. Run Program 1 again to verify the adjustments.

3-7. GENERAL OPERATING INSTRUCTIONS

WARNING

Before the Carrier Noise Test Set is switched on, all protective earth terminals, extension cords, autotransformers, and devices connected to the instrument should be connected to a protective earth grounded socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.

CAUTION

Before the Carrier Noise Test Set is switched on, it must be set to the same line voltage as the power source or damage to the instrument may result.

3-8. Turn On

Turn-on Procedure. If the Carrier Noise Test Set is already plugged in, set the LINE switch to ON.

If the power cable is not plugged in, follow these instructions.

On the rear panel:

1. Check the line voltage selection card for correct voltage selection.
2. Check the fuse for correct current rating. The current rating is printed on the line power module label.
3. Plug in the power cable.

On the front panel, set the LINE switch to ON.

Turn-on Sequence. The Carrier Noise Test Set performs a quick memory check (ROM and RAM) at turn-on. During this check, all front panel annunciators light for approximately 1.5 seconds to allow a quick visual inspection of each front panel annunciator. If a memory failure is detected the front panel annunciators will not light during the 1.5 second time period.

Following the memory check the Carrier Noise Test Set powers up as follows:

Measurement — ϕ, CW

Band Range — Band 1 (0.010—1.28 GHz)

Lock Bandwidth Factor — 100

NOTE

For the Carrier Noise Test Set to be operational it may require one or both of the following drive signals when making a phase noise measurement:

- *A synthesized 640 MHz signal*
- *A tunable 5 to 1280 MHz signal*

The drive signals can be supplied by an external RF source or the Carrier Noise Test Set can be configured to provide an internally generated 640 MHz signal that can supply the 640 MHz drive signal. The absolute system noise floor will be degraded close-in to the carrier when using the internally generated 640 MHz signal, compared to the 640 MHz signal being supplied by the HP 8662A Synthesized Signal Generator.

When using the Carrier Noise Test Set to make an AM noise measurement none of the drive signals are required.

The number of drive signals required is dependent on the measurement method chosen and the frequency of the signal under test.

The following table lists when the drive signals are required:

Drive Signal	Phase Detector Method		Frequency Discriminator Method	
	Frequency Range of Signal Under Test		Frequency Range of Signal Under Test	
	10 MHz to 1.28 GHz	1.28 GHz to 18 GHz	10 MHz to 1.28 GHz	1.28 GHz to 28 GHz
Fixed 640 MHz	Not needed	X	Not needed	X
Tunable 5—1280 MHz Source	X	X	Not needed	Not needed

X = Drive signal is needed.

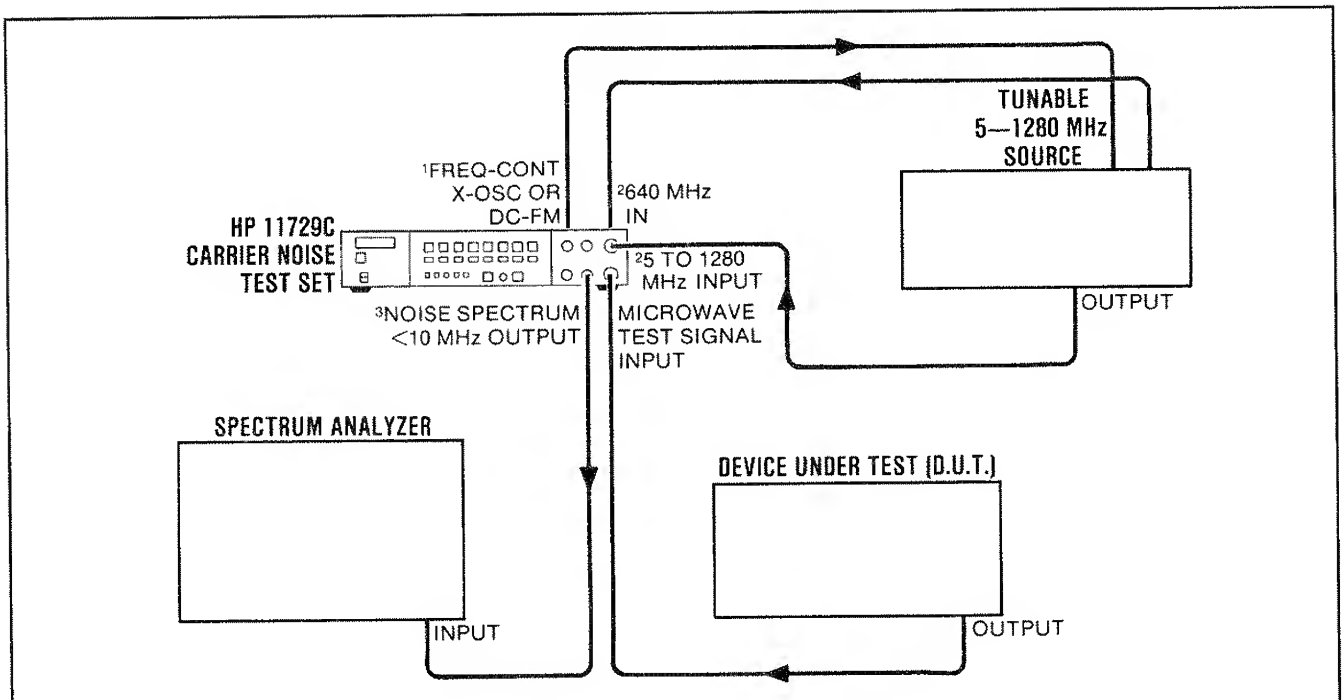
3-9. PHASE NOISE MEASUREMENT

3-10. Phase Detector Method

NOTE

The 640 MHz and 5-1280 MHz signals may come from the following sources:

- *Two synthesized sources.*
- *One synthesized source and one cavity tuned source.*
- *Two cavity tuned sources.*



[1]The FREQ-CONT signal can be connected to the source supplying the 5—1280 MHz signal or the device under test.

[2]Two sources can supply the 640 MHz and 5—1280 MHz signals. For important information see the note at the beginning of paragraph 3-10

[3]The NOISE SPECTRUM, (<1 MHz or <10 MHz) that is connected to the spectrum analyzer, depends on the offset of interest and the input impedance of the spectrum analyzer.

Figure 3-4. Interconnections to the Carrier Noise Test Set when making a Phase Noise Measurement (Using the Phase Detector Method)

Phase Detector Method (cont'd)

Each configuration will have a different absolute system noise floor. The absolute system noise floor is a function of the noise contributions from the 640 MHz signal, 5-1280 MHz signal and the HP 11729C.

To calculate the absolute system noise floor use the following formula:

$$\mathcal{L}_{\text{system}} = 10 \log \left(N^2 \times 10^{\frac{\mathcal{L}_1}{10}} + 10^{\frac{\mathcal{L}_2}{10}} + 10^{\frac{\mathcal{L}_3}{10}} \right)$$

where

N = center frequency of selected filter/640 MHz

$\mathcal{L}_1$ = absolute SSB phase noise of the 640 MHz reference signal (dBc/Hz)

$\mathcal{L}_2$ = absolute SSB phase noise of the 5-1280 MHz tunable signal dBc/Hz

$\mathcal{L}_3$ = residual noise of the HP 11729C (dBc/Hz)

Two synthesized sources with their crystal time bases connected externally will give the lowest close in noise floor performance. When a synthesized source and a cavity tuned source are used the 640 MHz signal should come from the synthesized source. A synthesized source is desired for the 640 MHz signal since the 640 MHz signal multiplied to a microwave frequency is the major contributor to the system noise floor. If the cavity tuned source selected has a wide DC-FM bandwidth and Loop Holding Range this will help to phase lock a drifting source. If two cavity tuned sources are used the absolute system noise floor close-in will be degraded but the noise floor further out will be better.

1. Figure 3-4 shows the interconnections to the Carrier Noise Test Set when making a phase noise measurement.

2. Be sure the LINE MODULE, on the rear panel, is set to the available line voltage. If it needs to be changed see Figure 2-1 in Section II.

Phase Detector Method (cont'd)

3. Plug the Carrier Noise Test Set into the available line supply.

4. Turn the Carrier Noise Test Set on and allow a 30 minute warm-up before making any measurements.

5. If the microwave test signal is in the range of 0.010—1.28 GHz go to step 6. If the microwave test signal is greater than 1.28 GHz follow the instructions for step 5.

   Using a coaxial cable connect the synthesized 640 MHz source to the 640 MHz IN connector on the rear panel.

   To configure and use the internal 640 MHz oscillator connect the 640 MHz OUT connector to the 640 MHz IN connector with the cable-attenuator assembly (HP 11729-60096 or HP 11729-60098 [Option 140]) provided. Both connectors are on the rear panel. Be sure to make the connection using the cable-attenuator assembly that was shipped with the Carrier Noise Test Set.

   NOTE

   The absolute system noise floor will be degraded close-in to the carrier when using the internally generated 640 MHz signal, compared to the 640 MHz signal being supplied by the HP 8662A Synthesized Signal Generator.

6. Using a coaxial cable connect the FREQ-CONT X-OSC or FREQ-CONT DC-FM, on the rear panel, to an electronic frequency control port on either the tunable 5—1280 MHz source or the device under test.

   Either FREQ-CONT X-OSC or FREQ-CONT DC-FM can be used to control the voltage controlled oscillator (VCO) of the phase lock loop. The output chosen will depend on the control voltage required for the VCO. FREQ-CONT X-OSC has an output voltage of −10 volts dc to +10 volts dc. FREQ-CONT DC-FM has an output voltage of −1 volt dc to +1 volt dc. When either output is used the device under test and the tunable 5—1280 MHz source will be maintained in phase quadrature (that is, 90 degrees out of phase).

7. Using a coaxial cable connect the tunable 5—1280 MHz source to the 5—1280 MHz IN connector on the front panel. Be sure the tunable 5 to 1280 MHz source is set to 0 dBm.

8. Using a coaxial cable connect the device under test to the MICROWAVE TEST SIGNAL INPUT on the front panel.

9. Using a coaxial cable connect one of the NOISE SPECTRUM OUTPUTS <1 MHz or <10 MHz, on the front panel, to a spectrum analyzer. The <1 MHz OUTPUT is useful for measuring phase noise at offsets from dc to 1 MHz. The <10 MHz OUTPUT is useful for measuring phase noise at offsets from 10 Hz to 10 MHz and has 40dB of gain over the <1 MHz OUTPUT. The <1 MHz OUTPUT has an output impedance of 600Ω and the <10 MHz OUTPUT has an output impedance of 50Ω.

   NOTE

   Do not use the <10 MHz NOISE SPECTRUM OUTPUT for test signals ±20 MHz around the BAND CENTER frequency. High feedthrough signals (mixer sum products and LO signals) saturate the Low Noise Amplifier in the Carrier Noise Test Set and possibly the spectrum analyzer.

   Do not use the <1 MHz NOISE SPECTRUM OUTPUT for test signals ±5 MHz around the BAND CENTER frequency. LO feedthrough may possibly saturate the spectrum analyzer.

   For test signals ±5 MHz to 10 MHz around the BAND CENTER frequency the measured noise level will be 0 dBm to +3 dBm greater than the actual level. The error is caused by an impedance change on the input of the internal Low Noise Amplifier.

   For test signals ±10 MHz to 20 MHz around the BAND CENTER frequency the measured noise level will be 0 dBm to +1 dBm greater than the actual level. Again the error is caused by an impedance change on the input of the Low Noise Amplifier.

   Therefore, the <1 MHz OUTPUT can be used for test signals ±5 MHz to 20 MHz around the BAND CENTER frequency by subtracting the maximum error amount from the measured level.

10. To select a PHASE NOISE MEASUREMENT press the MODE button ,on the front panel, until the LED opposite ϕ, CW is illuminated.

Phase Detector Method (cont'd)

11. Set the LOCK BANDWIDTH FACTOR to 100.

12. Select the BAND RANGE that includes the frequency of the signal under test. For example, if the frequency of the signal under test is 10 GHz then the BAND RANGE would be 8.32—10.88 GHz. Select this filter.

13. Connect the IF OUTPUT, on the front panel, to a spectrum analyzer.

NOTE

Present at the IF OUTPUT will be the IF signal (signal under test minus the BAND CENTER frequency of the BAND RANGE chosen), IF harmonics and spurious signals. The signal with the highest amplitude is the desired signal.

Adjust the spectrum analyzer to determine the frequency of the IF OUTPUT (signal under test minus the BAND CENTER frequency of the BAND RANGE chosen). Set the tunable 5—1280 MHz source to the frequency read on the spectrum analyzer. Disconnect the IF OUTPUT from the spectrum analyzer.

NOTE

The following applys to those users with an IF signal of 625 MHz to 655 MHz.

IF signals between 625 MHz to 655 MHz cause a high level spur from one or both of the NOISE SPECTRUM OUTPUTS. When setting the reference level on the spectrum analyzer, during calibration, use the beat note and not the high level spur. The high level spur is a mixer product from the 640 MHz rear panel input and the 5-1280 MHz front panel input. The spur is within the passband of the NOISE SPECTRUM OUTPUT, so it does not get filtered out.

For example: with a 635 MHz IF signal you can expect a 5 MHz high level spur from the <10 MHz OUTPUT.

14. **Calibration.** At calibration a reference level is being set on the spectrum analyzer. The Carrier Noise Test Set's effect on a given noise input is being used to set the reference level. Below is an example of how to set the reference level on the spectrum analyzer for making a phase noise measurement:

a. Increase the tunable 5—1280 MHz source by 50 kHz. This will produce a 50 kHz beat note at the NOISE SPECTRUM OUTPUTS. This 50 kHz offset is given as an example only. A different offset may be required because of the frequency range of the spectrum analyzer or to make it easier to calibrate with a fast drifting source.

b. Add 40 dB of attenuation to the tunable 5—1280 MHz signal.

CAUTION

Do not set the attenuation any higher than −30 dBm. −30 dBm or lower is necessary for a linear calibration.

c. Adjust the spectrum analyzer so the 50 kHz beat note is on the screen and placed at a convenient reference point. Record the level of the reference point for use later.

d. This reference point represents the power in the carrier minus 40 dB.

e. Remove the 50 kHz offset and 40 dB of attenuation from the tunable 5—1280 MHz signal.

f. The spectrum analyzer is now ready to be used for making a measurement.

15. **Phase Locking.** The following discussion describes two methods for phase locking the device under test and the tunable 5—1280 MHz source.

When the device under test is a synthesized or very stable source, phase locking can be accomplished using either the FREQ-CONT X-OSC or FREQ-CONT DC-FM connector and the following procedure. The FREQ-CONT X-OSC or FREQ-CONT DC-FM connector is connected to the electronic frequency control input of the tunable 5—1280 MHz source or the device under test.

The connector chosen will depend on the tuning voltage required by the loop VCO (device under test or the 5—1280 MHz source).

a. Set the LOCK BANDWIDTH FACTOR to 100.

b. On the front panel press then release CAPTURE.

Phase Detector Method (cont'd)

c. If phase lock is acquired, a green LED will be illuminated in the center of the phase lock indicator, on the left side of the front panel.

d. If the two sources did not phase lock proceed as follows. Connect the <10 MHz OUTPUT, on the front panel, to a spectrum analyzer with a 50 Ohm input impedance and a bandwidth that includes 10 Hz to 10 MHz. Adjust the spectrum analyzer to view the beat note. The beat note is the difference between the tunable 5—1280 MHz signal and the microwave test signal minus the BAND CENTER frequency of the BAND RANGE chosen.

Hold CAPTURE in while tuning the tunable 5—1280 MHz source until a green LED is seen in the center of the phase lock indicator. The frequency resolution of the tunable 5—1280 MHz source should be <1/10 of the effective tuning range of it's crystal oscillator.

Figure 3-5 shows what the spectrum analyzer display should look like if the tunable 5—1280 MHz source is being tuned in the direction of phase lock (that is, towards dc) or tuned away from phase lock. Figure 3-6 shows what the phase lock indicator, on the front panel, should be like as the two sources get closer to phase lock. Release CAPTURE and the two sources should now be phase locked.

e. If the device under test and the tunable 5—1280 MHz source are still not phase locked increase the LOCK BANDWIDTH FACTOR to 1k. Press and release CAPTURE. The two sources should now be phase locked. If phase lock was aquired go to step g. If phase lock was not aquired go to step f.

NOTE

If the HP 8662A is used as the tunable 5-1280 MHz source, and the system is locked using the crystal of the HP 8662A, the 1k LOCK BANDWIDTH FACTOR may cause an unstable phase lock loop for microwave test signals greater than 5 GHz. If the loop is unstable lower the LOCK BANDWIDTH FACTOR to 100. If the loop is still unstable try locking using DC-FM.

f. If the two sources are still not phase locked try locking using a loop VCO with a larger electronic tuning range.

g. Reduce the LOCK BANDWIDTH FACTOR if close-in measurements are desired. Make sure the phase lock indicator remains green or stays within the wide section of the indicator. If lock is broken, hold CAPTURE in while tuning the tunable 5—1280 MHz source until the center green LED is illuminated on the phase lock indicator. When the green LED is illuminated release CAPTURE. If the green LED doesn't stay illuminated increase the LOCK BANDWIDTH FACTOR and press CAPTURE to re-enable lock. For accurate measurements reduce the loop bandwidth to below the lowest offset frequency of interest. Use the following equation to find the maximum loop bandwidth for the offset frequency of interest.

NOTE

Phase noise is suppressed within the phase lock loop bandwidth.

$$\text{Nominal loop bandwidth} = \frac{f_{dut} \times LBF \times K_o}{100} \text{ (Hz)}$$

f = frequency(Hz)
dut = device under test
LBF = LOCK BANDWIDTH FACTOR
K_o = The VCO slope in Hz/volt (For the HP 8662A K_o equals 10^{e1} Hz/volt)

When the device under test is a free-running source and the loop VCO has a DC-FM feature use the following procedure.

h. Connect the FREQ-CONT X-OSC or FREQ-CONT DC-FM connector to the electronic frequency control input of the loop VCO. The connector used will depend on the tuning voltage required for DC-FM.

Set the loop VCO as follows:

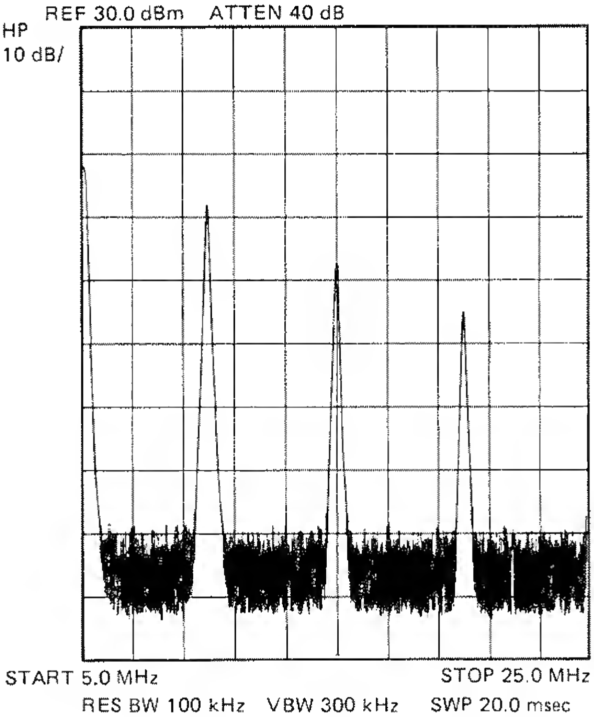
— DC-FM

— 50 kHz deviation

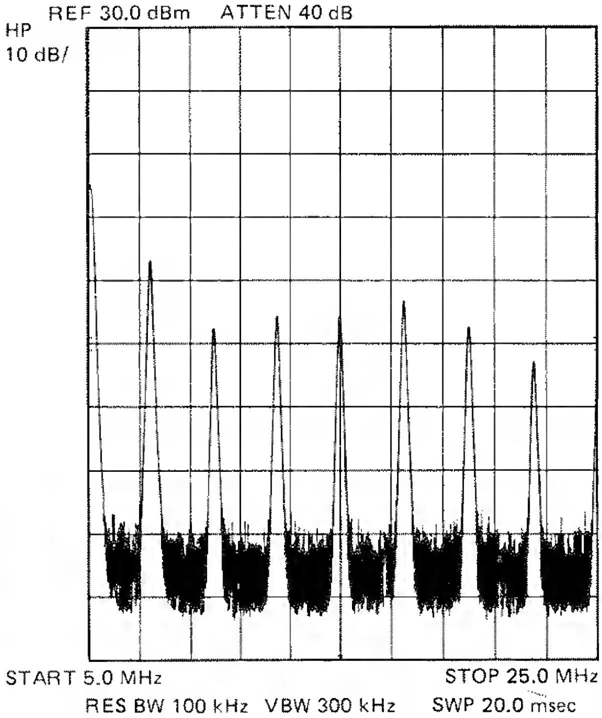
— Set amplitude to 0 dBm

i. Set the LOCK BANDWIDTH FACTOR to 100.

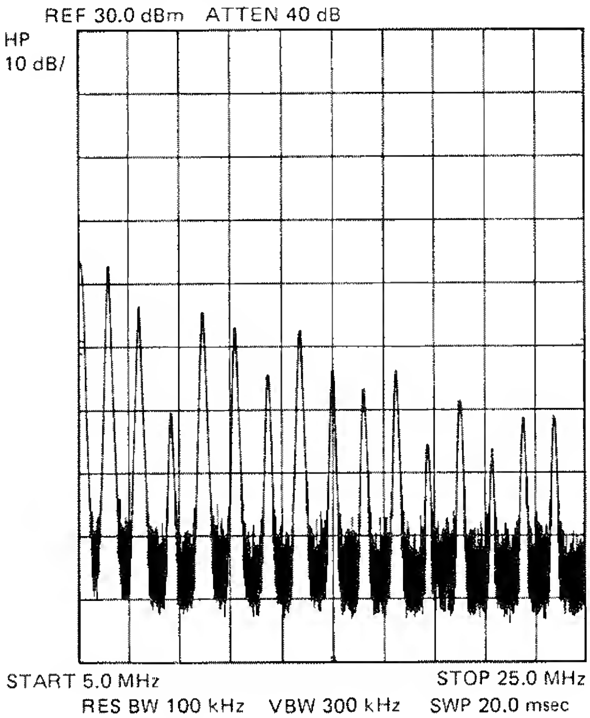
j. Connect the <10 MHz OUTPUT, on the front panel, to a spectrum analyzer with a 50 Ohm input impedance and a bandwidth that



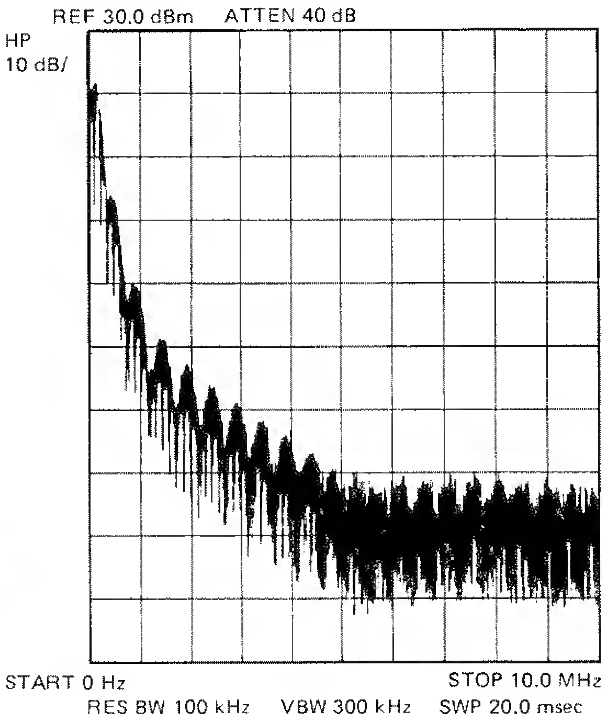
The 5 to 1280 MHz source and device under test are 5 MHz from phase lock (quadrature).



The 5 to 1280 MHz source and device under test are 2.5 MHz from phase lock (quadrature).



The 5 to 1280 MHz source and device under test are 1.25 MHz from phase lock (quadrature).



The 5 to 1280 MHz source and device undee test are close to phase lock (quadrature).

Figure 3-5. Spectrum Analyzer Displays Used for Acquiring Phase Lock (Quadrature)

Phase Detector Method (cont'd)

includes 10 Hz to 10 MHz. Adjust the spectrum analyzer to view the beat note. The beat note is the difference between the tunable 5—1280 MHz signal and the microwave test signal minus the BAND CENTER frequency of the BAND RANGE chosen.

Hold CAPTURE in while tuning the loop VCO until a green LED is seen in the center of the phase lock indicator. The frequency resolution of the loop VCO should be <1/10 of the effective tuning range of it's crystal oscillator.

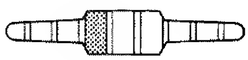
Figure 3-5 shows what the spectrum analyzer display should look like if the loop VCO is being tuned in the direction of phase lock (that is, towards dc) or tuned away from phase lock. Figure 3-6 shows what the phase lock indicator, on the front panel, should be like as the two sources get closer to phase lock. Release CAPTURE and the two sources should now be phase locked.

If the sources drift out of phase lock repeat the procedure, then after releasing CAPTURE immediately increase the FM deviation to 100 kHz. Again be sure the two sources stay phase locked.

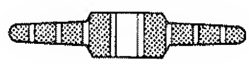
k. If the two sources are still not phase locked repeat the preceeding step, each time increasing the FM deviation until maximum deviation is reached. If maximum deviation is reached and the two sources still will not stay locked, repeat step j but this time increase the LOCK BANDWIDTH FACTOR until the two sources are phase locked. When the two sources are phase locked go to step m.

l. If the two sources are still not locked try making the measurement using the Frequency Discriminator Method.

m. Reduce the LOCK BANDWIDTH FACTOR if close-in measurements are desired. Make sure the phase lock indicator remains green or stays within the wide section of the indicator.



A solid red bar, to the left of the center green bar, indicates the signal under test and the tunable 5—1280 MHz signal are not phase locked and >100 kHz apart.



With the display all illuminated the signal under test and the tunable 5—1280MHz signal are <100 kHz apart.

The red LEDs, within the display, step one at a time as the signal under test and the tunable 5—1280 MHz signal approach quadrature.

A green LED in the center of the display indicates that the signal under test and the tunable 5—1280 MHz signal are in quadrature.

Figure 3-6. Front Panel Phase Lock (Quadrature) Indicator

Phase Detector Method (cont'd)

If lock is broken, hold CAPTURE in while tuning the tunable 5—1280 MHz source until the center green LED is illuminated on the phase lock indicator. When the green LED is illuminated release CAPTURE. If the green LED doesn't stay illuminated increase the LOCK BANDWIDTH FACTOR and press CAPTURE to re-enable lock. For accurate measurements reduce the loop bandwidth to below the lowest offset frequency of interest. Use the following equation to find the maximum loop bandwidth for the offset frequency of interest.

NOTE

Phase noise is suppressed within the phase lock loop bandwidth.

$$\text{Nominal loop bandwidth} = \frac{f_{dut} \times LBF \times K_o}{100}$$

f = Frequency (Hz)
dut = Device under test
LBF = Lock Bandwidth Factor
K_o = The VCO slope in Hz/volt (For the HP 8662A K_o equals 10^{-1} Hz/volt)

16. **Measurement.** With the spectrum analyzer calibrated and phase lock acquired, a phase noise measurement may now be made. When making a phase noise measurement the following items must be taken into consideration:

— Set the spectrum analyzer span to cover the offset frequency of interest.

— Do not change the input sensitivity of the spectrum analyzer. Changing the spectrum analyzer input sensitivity between calibration and measurement decreases the measurement accuracy. For better accuracy recalibrate on a lower level calibration signal. See step 14 of this procedure.

— Select an appropriate resolution bandwidth for the the chosen frequency span (at least <1/10 frequency span).

— Because phase noise is a random quantity, some sort of averaging or video filtering is desired.

— In general, it is not advisable to take measurements on a portion of the spectrum analyzer display where the noise level is falling very rapidly (>20 dB per major division). Therefore, increase the frequency span to where the offset frequency of interest is in the center of the spectrum analyzer display.

— It is not recommended to measure noise levels that are in the bottom 10 dB of the display.

— In general, if spurious signals are seen when making a measurement they can be disregarded. Reduce the resolution bandwidth if necessary to determine the noise level near the spur. Be careful not to measure on a spur.

— With the preceeding considerations in mind, a measurement can now be made. Measure down from the reference point (step 14 c.) at the offset of interest.

17. **Corrections**[1]. Subtract the reference level set during calibration from the level of the noise measured at the offset of interest. Sum this value and the following correction factors.

— Minus 40 dB for the attenuation added during calibration.

— Minus 6 dB for conversion to $\mathcal{L}(f)$.

— Minus 10 log(1.2 x spectrum analyzer resolution bandwidth). This is for normalization to a 1 Hz noise equivalent bandwidth. The result is in dB.

— Plus 2.5 dB is the correction for log amplifiers and peak detectors used in an analog spectrum analyzer.

— Plus loop noise suppression[2] at the appropriate offset frequency. Only add loop noise suppression when making a measurement inside the loop bandwidth.

Below is an example of how to calculate the correct amount of phase noise:

−67 dBm = measured phase noise.
−10 dBm = reference level set during calibration.
−40 dB = attenuation added during calibration.

[1]For a complete explanation of the correction factors see Appendix A.

[2]See Appendix B to determine the phase lock loop transfer characteristic and the amount of loop noise suppression.

Phase Detector Method (cont'd)

−6 dB = $\mathcal{L}$(f) conversion factor

−20.8 dB = 10 log (1.2 x spectrum analyzer resolution bandwidth).

+2.5 dB = if an analog spectrum analyzer is used.

+20 dB = for loop noise suppression if the measurement is made within the loop bandwidth.

−67 dBm − (−10 dBm) + (−40 dB) + (−6 dB) + (−20.8 dB) + (2.5 dB) + (20 dB) = −101.3 dBc/Hz

The actual amount of phase would then be −101.3dBc/Hz.

After applying these correction factors the actual amount of phase noise is known for the particular frequency offset.

3-11. Frequency Discriminator Method

1. Figure 3-7 shows interconnections to the Carrier Noise Test Set when making a phase noise measurement.
2. Be sure the LINE MODULE on the rear panel is set to the available line voltage. If it needs to be changed see Figure 2-1 in Section II.
3. Plug the Carrier Noise Test Set into the available line supply.
4. Turn the Carrier Noise Test Set on and allow a 30 minute warm-up before making any measurements.
5. If the microwave test signal is from 0.010—1.28 GHz go to step 6. If the microwave test signal is greater than 1.28 GHz follow the instructions for step 5.

   Using a coaxial cable connect a 640 MHz source to the 640 MHz IN connector on the rear panel.

   To configure and use the internal 640 MHz oscillator connect the 640 MHz OUT connector to the 640 MHz IN connector with the cable-attenuator assembly (HP 11729-60096 or HP 11729-60098 [Option 140]) provided. Both connectors are on the rear panel. Be sure to make the connection using the cable-attenuator assembly that was shipped with the Carrier Noise Test Set.

NOTE

The absolute system noise floor will be degraded close-in to the carrier when using the internally generated 640 MHz signal compared to the 640 MHz sig-

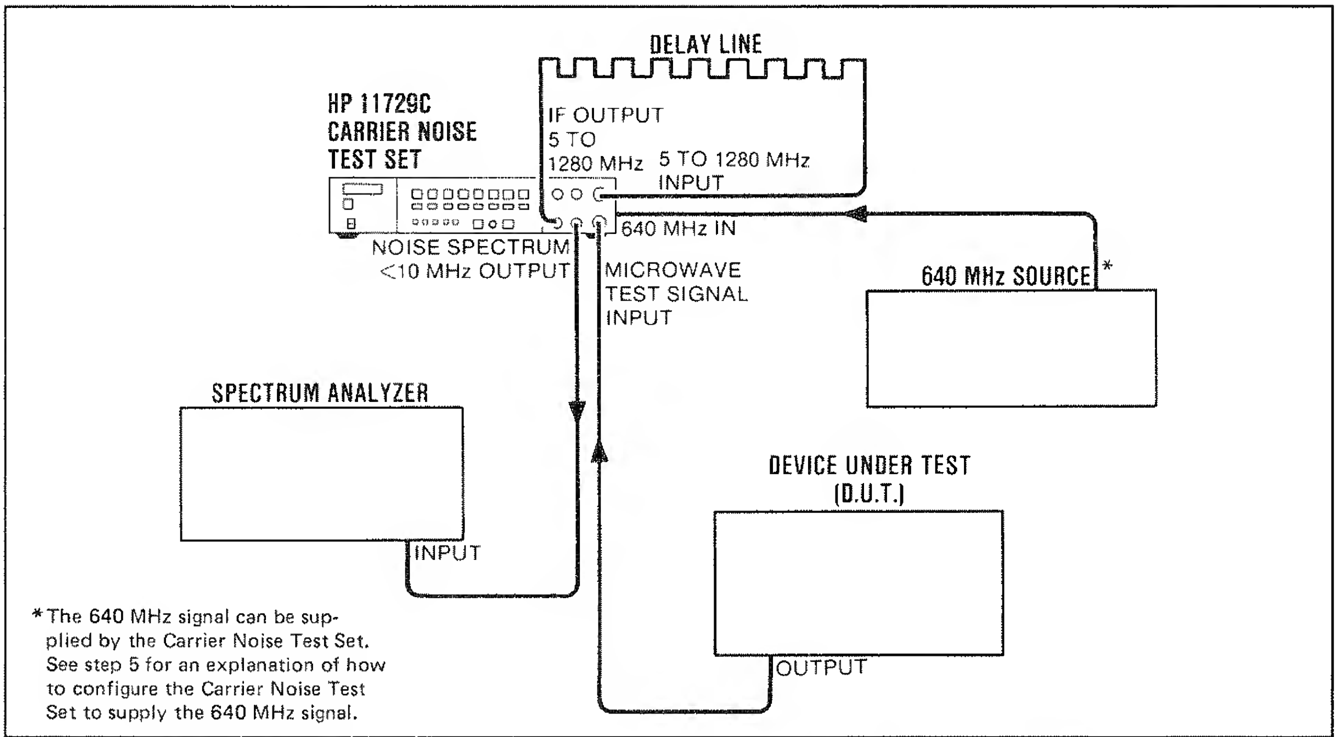


Figure 3-7. Interconnections to the Carrier Noise Test Set When Making a Phase Noise Measurement (Using the Frequency Discriminator Method)

Frequency Discriminator Method (cont'd)

nal being supplied by the HP 8662A Synthesized Signal Generator.

6. Using a coaxial cable connect the device under test to the MICROWAVE TEST SIGNAL INPUT connector on the front panel.
7. Connect the IF OUTPUT, on the front panel, to a spectrum analyzer.
8. To select a PHASE NOISE MEASUREMENT press the MODE button, on the front panel, until the LED opposite ϕ, CW is illuminated.
9. Select the BAND RANGE that includes the frequency of the signal under test. For example, if the frequency of the signal under test is 10 GHz then the BAND RANGE would be 8.32-10.88 GHz. Select this filter.
10. The LOCK BANDWIDTH FACTOR can be at any setting.
11. Using a spectrum analyzer determine the frequency at the IF OUTPUT (signal under test minus the BAND CENTER frequency of the BAND RANGE chosen).

    NOTE

    A number of signals will be present at the IF OUTPUT. The signals present will include the IF signal (signal under test minus the BAND CENTER frequency of the BAND RANGE chosen), IF harmonics and spurious signals. The signal with the highest amplitude is the desired signal.

    Note the frequency for use later. Disconnect the IF OUTPUT from the spectrum analyzer.

12. Connect a suitable delay line (such as a length of flexible RF cable) between the IF OUTPUT and the 5—1280 MHz INPUT, on the front panel. The length of delay line effects the sensitivity of the descriminator. In general, sensitivity increases with cable length. 1.5 ns/foot is the approximate amount of delay for flexible RF cable when the cable dielectric is Teflon.
13. Set the tunable 5—1280 MHz source to the following conditions:

    Frequency: Same as measured in step 11.

    Amplitude: −10 dBm

    Modulation: FM 1 kHz rate

14. Connect the tunable 5—1280 MHz signal to the input of the spectrum analyzer.
15. Set the FM sidebands on the tunable 5—1280 MHz signal to a convenient carrier to sideband ratio. The ratio should be at least 20 dB at a 0.2 kHz rate. Note the difference between the carrier and sidebands for use later.
16. Disconnect the device under test from the Carrier Noise Test Set and the tunable 5—1280 MHz source from the spectrum analyzer. Connect the tunable 5 to 1280 MHz source to the MICROWAVE TEST SIGNAL INPUT connector on the Carrier Noise Test Set. Enable the 0.010—1.28 GHz BAND RANGE.
17. Connect the <10 MHz OUTPUT, on the Carrier Noise Test Set front panel, to the spectrum analyzer.

    NOTE

    Do not use the <10 MHz NOISE SPECTRUM OUTPUT for test signals ±20 MHz around the BAND CENTER frequency. High feedthrough signals (mixer sum products and LO signals) saturate the Low Noise Amplifier in the Carrier Noise Test Set and possibly the spectrum analyzer.

    Do not use the <1 MHz NOISE SPECTRUM OUTPUT for test signals ±5 MHz around the BAND CENTER frequency. LO feedthrough may possibly saturate the spectrum analyzer.

    For test signals ±5 MHz to 10 MHz around the BAND CENTER frequency the measured noise level will be 0 dBm to +3 dBm greater than the actual level. The error is caused by an impedance change on the input of the internal Low Noise Amplifier.

    For test signals ±10 MHz to 20 MHz around the BAND CENTER frequency the measured noise level will be 0 dBm to +1 dBm greater than the actual level. Again the error is caused by an impedance change on the input of the Low Noise Amplifier.

    Therefore, the <1 MHz OUTPUT can be used for test signals ±5 MHz to 20 MHz around the BAND CENTER frequency by subtracting the maximum error amount from the measured level.

Frequency Discriminator Method (cont'd)

18. Increase or decrease the frequency of the tunable 5—1280 MHz source until a green LED is seen in the center of the phase lock indicator on the Carrier Noise Test Set. The frequency resolution of the tunable 5—1280 MHz source should be <1/10 of $1/\tau_d$. τ_d is the time delay caused by the cable connected from the IF OUTPUT to the 5—1280 MHz IN. Once quadrature is established adjust the spectrum analyzer to position the 1 kHz FM sideband at the top line on the spectrum analyzer. Note the level of the 1 kHz sideband for use later.

19. Disconnect the tunable 5—1280 MHz source from the Carrier Noise Test Set. Connect the device under test to the MICROWAVE TEST SIGNAL INPUT connector on the Carrier Noise Test Set. Select the proper BAND RANGE for the frequency of the signal under test.

20. Increase or decrease the length of the delay line or the frequency of the device under test to establish quadrature. The frequency resolution of the device under test should be <1/10 of $1/\tau_d$. When quadrature is set a green LED will be illuminated in the center of the phase lock indicator on the Carrier Noise Test Set.

21. **Measurement.** With calibration completed a measurement can now be made. When making a phase noise measurement the following items must be taken into consideration:

    — The operator should be aware that voltage fluctuations caused by frequency fluctuations are being measured. Phase fluctuations are not being measured.

    — Set the spectrum analyzer span to cover the offset frequency of interest.

    — Do not change the input sensitivity of the spectrum analyzer. Changing the spectrum analyzer input sensitivity between calibration and measurement decreases the measurement accuracy. For better accuracy recalibrate on a lower level calibration signal. See steps 14—18 to recalibrate.

    — Select a resolution bandwidth that is appropriate for the chosen frequency span (at least <1/10 frequency span).

    — Because phase noise is a random quantity, some sort of averaging or video filtering is desired.

    — In general, it is not advisable to take measurements on a portion of the spectrum analyzer display where the noise level is falling very rapidly (>20 dB per major division). Therefore, increase the frequency span to where the offset frequency of interest is in the center of the spectrum analyzer display.

    — It is not recommended to measure noise levels that are in the bottom 10 dB of the display.

    — In general, if spurious signals are seen when making a measurement they can be disregarded. If necessary, reduce the resolution bandwidth to determine the noise level close to the spur.

    — With the preceding considerations in mind, a measurement can now be made. Measure down from the reference point (step 18) at the offset of interest.

22. **Corrections**[1]. Subtract the reference level set in step 18 from the measured level. Sum this result with the following correction factors:

    — Minus the carrier to sideband ratio set in step 15.

    — Minus 20 log (f_{off}/1 kHz) dB. This formula will convert frequency fluctuations at any offset to $\mathcal{L}(f)$ dBc. $\mathcal{L}(f)$ dBc = 10 log Pssb/Ps where Pssb is the power density (in one phase modulation sideband) and Ps is the total signal power.

    — Minus 10 log (1.2 x spectrum analyzer reslution bandwidth). This is for normalization to a 1 Hz noise equivalent bandwidth. The result is in dB.

    — Plus 2.5 dB is the correction for log amplifiers and peak detectors used in an analog spectrum analyzer.

    Below is an example of how to calculate the correct amount of phase noise:

    −67 dBm = measured phase noise.

    −10 dBm = reference level set during calibration.

    −20 dB = carrier to sideband ratio set in step 15.

    −10 dB = 20 log (f_{off}/1 kHz) db. This formula is used to convert frequency fluctuations at any offset to $\mathcal{L}(f)$ dBc.

[1] For a complete explanation of the correction factors see Appendix A.

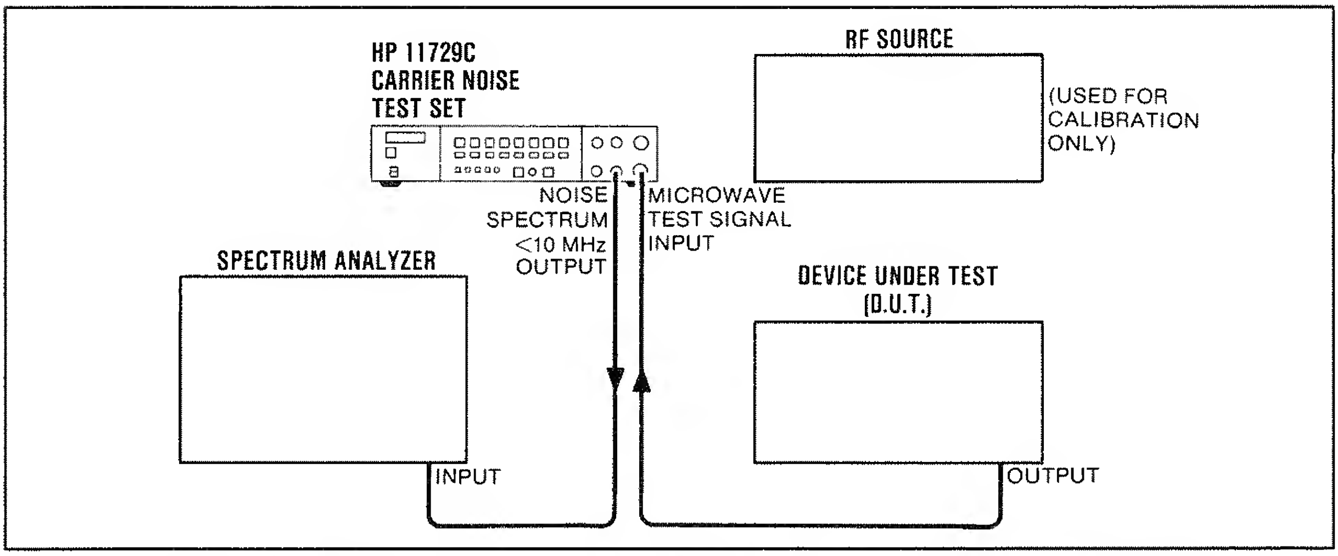


Figure 3-8. Interconnections to the Carrier Noise Test Set When Making an AM Noise Measurement

Frequency Discriminator Method (cont'd)

-20.8 dB = 10 log (1.2 x spectrum analyzer resolution bandwidth).

$+2.5$ dB = if an analog spectrum analyzer is used.

$-67\,\text{dBm} - (-10\,\text{dBm}) + (-20\,\text{dB}) + (-10\,\text{dB}) + (-20.8\,\text{dB}) + (2.5\,\text{dB}) = -105.3\,\text{dBc/Hz}$

The actual amount of phase would then be -105.3 dBc/Hz.

After applying these correction factors the actual amount of phase noise will be known at a particular offset, provided the sensitivity, set-up with the delay line, is lower than the phase noise of the device under test.

3-12. AM Measurement (Option 130 only)

1. Figure 3-8 shows interconnections to the Carrier Noise Test Set when making an AM noise measurement.
2. Be sure the LINE MODULE on the rear panel is set to the available line voltage. If it needs to be changed see Figure 2-1 in Section II.
3. Plug the Carrier Noise Test Set into the available line supply.
4. Turn the Carrier Noise Test Set on and allow a 30 minute warm-up before making any measurements.
5. Set the device under test to the frequency of interest. Measure the power out of the device under test with a power meter. Note the power level for use later.
6. Set the RF source to 1 GHz.
7. Set the power of the RF source to the same power as that measured in step 5. Use a power meter to measure the power.
8. Connect the RF source to a spectrum analyzer. Set the displayed RF source to a convenient reference point on the spectrum analyzer.
9. Amplitude modulate the RF source at a 1 kHz rate. Adjust the AM level so the AM sidebands are -40 dBc.

NOTE

If the RF source is a non-synthesized source the modulating rate may have to be increased. This is so the AM sidebands can be seen on the spectrum analyzer display.

10. Press the MODE button, on the front panel of the Carrier Noise Test Set, until the LED next to AM, CW is illuminated. No other Carrier Noise Test Set front panel functions are used.
11. Disconnect the RF source from the spectrum analyzer. Connect the RF source to the MICROWAVE TEST SIGNAL INPUT connector on the front panel of the Carrier Noise Test Set.
12. Connect the <10 MHz OUTPUT, on the front panel of the Carrier Noise Test Set, to the spectrum analyzer.

AM Measurements (Option 130 only) (cont'd)

13. Set a reference point with the demodulated 1 kHz signal on the spectrum analyzer. Note the reference level for use later.

14. Disconnect the RF source from the Carrier Noise Test Set. Connect the device under test to the MICROWAVE TEST SIGNAL INPUT connector on the front panel of the Carrier Noise Test Set.

15. **Measurement.** With calibration completed a measurement can now be made. When making an AM measurement the following items must be taken into consideration:

    — Set the spectrum analyzer span to cover the offset frequency of interest.

    — Do not change the input sensitivity of the spectrum analyzer. Changing the spectrum analyzer input sensitivity between calibration and measurement decreases the measurement accuracy. For better accuracy recalibrate on a lower level calibration signal. Use steps 5—13 to recalibrate the spectrum analyzer.

    — Select a resolution bandwidth that is appropriate for the chosen frequency span (at least <1/10 frequency span).

    — Because AM noise is a random quantity, some sort of averaging or video filtering is desired.

    — In general, it is not advisable to take measurements on a portion of the spectrum analyzer display where the noise level is falling very rapidly (>20 dB per major division). Therefore, increase the frequency span to where the offset frequency of interest is in the center of the spectrum analyzer display.

    — It is not recommended to measure noise levels that are in the bottom 10 dB of the display.

    — In general, if spurious signals are seen when making a measurement they can be disregarded. If necessary, reduce the resolution bandwidth to determine the noise level close to the spur.

    — A measurement can now be made. Measure down from the reference point set in step 13 at the offset of interest.

16. **Corrections**[1]. Subtract the reference level in step 13 from the measured level. Sum this result with the following correction factors:

    — Minus 40 dB (The carrier to sideband ratio set in step 9)

    — Minus 10 log (1.2 x specturm analyzer resolution bandwidth). This is for normalization to a 1 Hz noise equivalent bandwidth. The result is in dB.

    — Plus 2.5 dB is the correction for log amplifiers and peak detectors used in an analog spectrum analyzer.

    Below is an example of how to calculate the correct amount of AM noise:

    −67 dBm = measured AM noise.

    −10 dBm = reference level set during calibration.

    −40 dB = The carrier to sideband ratio set in step 9.

    −20.8 dB = 10 log (1.2 x spectrum analyzer resolution bandwidth).

    +2.5 dB = if an analog spectrum analyzer is used.

    $-67\ \text{dBm} - (-10\ \text{dBm}) + (-40\ \text{dB}) + (-20.8\ \text{dB}) + (2.5\ \text{dB}) = -115.3\ \text{dBc/Hz}$

    The actual amount of AM noise would then be −115.3 dBc/Hz.

[1]For a complete explanation of the correction factors see Appendix A.

Table 3-3. HP-IB Message Reference Table (1 of 2)

HP-IB Message	Applicable	Response	Related Commands & Controls	Interface Functions
Data	Yes	All Carrier Noise Test Set functions available in local, except the LINE switch, are bus-programmable.		AH1,SH1, T5, TE0, L3, LE0
Trigger	No	The Carrier Noise Test Set has no trigger capability.		DT0
Clear	Yes	The clear message sets the Carrier Noise Test Set to the following conditions: Filter 1 ON Phase Lock Bandwidth 100 Hz Phase noise measurement Capture OFF	DCL, SDC	DC1
Remote	Yes	Remote mode is enabled when the REN bus control line is true. However, remote mode is not entered until the first time the Carrier Noise Test Set is addressed to listen. The front-panel REMOTE annunciator lights when the instrument is actually in the remote mode. No instrument settings or functions are changed, but all front-panel keys except LOCAL are disabled.	REN	RL1
Local	Yes	The Carrier Noise Test Set returns to local mode (front-panel control). Responds equally to the GTL bus command and the front-panel LOCAL key. When entering local mode, no instrument settings or functions are changed.	GTL	RL1
Local Lockout	Yes	Disables all front-panel keys including LOCAL. Only the controller can return the Carrier Noise Test Set to local (front-panel control).	LLO	RL1
Clear Lockout Set Local	Yes	The Carrier Noise Test Set returns to local (front-panel control) and local lockout is cleared when the REN bus control line goes false. When entering local mode, no instrument settings or functions are changed.	REN	RL1
Pass Control Take Control	No	The Carrier Noise Test Set has no controller capability.		C0
Require Service (SRQ)	Yes	If the SRQ mask is set (see Table 3-4 HP-IB Program Codes for a description of @) and one of the following conditions is valid, then SRQ will be true. 1) Invalid command 2) System in phase lock 3) System out of phase lock	SRQ	SR1

Table 3-3. HP-IB Message Reference Table (2 of 2)

HP-IB Message	Applicable	Response	Related Commands & Controls	Interface Functions
Status Byte	Yes	The Carrier Noise Test Set responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when addressed to talk. If the instrument is holding the SRQ control line true (issuing the Require Service message) bit 7 (RQS bit) in the Status Byte and the bit representing the condition causing the Require Service message to be issued will both be true. The bits in the Status Byte are latched but can be cleared by: 1) Removing the causing condition, and 2) reading the Status Byte.	SPE,	T5, TE0
Status Bit	Yes	The status bit is used in a parallel poll, when enabled, and the SRQ line is true. The status bit position and the sense of the status bit (true high or true low) is set by the computer, with the parallel poll configure message.	PPE, PPD, PPC, PPU	PP1
Abort	Yes	The Carrier Noise Test Set stops talking and listening.	IFC	T5, TE0, L3, LE0

Complete HP-IB compatibility as defined in IEEE Standard 488 (and the identical ANSI Standard MC1.1) is: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP1, DC1, DT0, C0.

Table 3-4. HP-IB Program Codes (Alphabetical Order by Code)

Program Code	Parameter
AM	AM noise measurement (Option 130 only)
@	Causes the Carrier Noise Test Set to accept the next data byte as a binary mask for the status byte. For example: A B C SRQ Mask | X | X | X | X | X | 1 | 1 | 1 | 1 | X = Don't care When position A is set to 1 and the corresponding bit in the status byte becomes 1, then RQS in the status byte and the SRQ line will be 1. Under the preceding condition a serial poll of the status byte will indicate that phase lock has been broken. When position B is set to 1 and the corresponding bit in the status byte becomes 1, then RQS in the status byte and the SRQ line will be 1. Under the preceding condition a serial poll of the status byte will indicate phase lock. When position C is set to 1 and the corresponding bit in the status byte becomes 1, then RQS in the status byte and the SRQ line will be 1. Under the preceding condition a serial poll of the status byte will indicate an invalid command has been received.
CA	CA1 = Capture active CA0 = Capture inactive
CS	Forces RQS and invalid command bit to zero in the status byte.
FT	Filter Bands 1 = FT1 7 = FT7 2 = FT2 8 = FT8 3 = FT3 9 = FT9 4 = FT4 10 = FT10 5 = FT5 11 = FT11 6 = FT6
LK	Phase Lock Range 1 Hz (1) = LK1 10 Hz (2) = LK2 100 Hz (3) = LK3 1 kHz (4) = LK4 10 kHz (5) = LK5
LP	When addressed to talk the Carrier Noise Test Set will send the current front panel settings in ASCII mnemonic string.
PH	Phase noise measurement
PU	Pulse measurement
?ID	When addressed to talk the Carrier Noise Test Set will send an ASCII string which contains the model number of the instrument and software revision number.
RM	When addressed to talk the Carrier Noise Test Set will send a single byte which is the binary pattern of the SRQ.
RO	When addressed to talk the Carrier Noise Test Set will send the ASCII mnemonics of the options installed.

Table 3-5. Allowable HP-IB Address Codes

Address Switches[1]					Listen Address Character	Talk Address Character	Decimal Equivalent[1]
A5	A4	A3	A2	A1			
0	0	0	0	0	SP	@	0
0	0	0	0	1	!	A	1
0	0	0	1	0	"	B	2
0	0	0	1	1	#	C	3
0	0	1	0	0	$	D	4
0	0	1	0	1	%	E	5
0	0	1	1	0	&	F	6 [2]
0	0	1	1	1	'	G	7
0	1	0	0	0	(	H	8
0	1	0	0	1	)	I	9
0	1	0	1	0	*	J	10
0	1	0	1	1	+	K	11
0	1	1	0	0	,	L	12
0	1	1	0	1	–	M	13
0	1	1	1	0	.	N	14
0	1	1	1	1	/	O	15
1	0	0	0	0	0	P	16
1	0	0	0	1	1	Q	17
1	0	0	1	0	2	R	18
1	0	0	1	1	3	S	19
1	0	1	0	0	4	T	20
1	0	1	0	1	5	U	21
1	0	1	1	0	6	V	22
1	0	1	1	1	7	W	23
1	1	0	0	0	8	X	24
1	1	0	0	1	9	Y	25
1	1	0	1	0	:	Z	26
1	1	0	1	1	;	[	27
1	1	1	0	0	<	\	28
1	1	1	0	1	=	]	29
1	1	1	1	0	>		30

[1]Decimal characters and the five address switches relate to the last five bits of both talk and listen addresses.

[2]Factory-set address.

SECTION IV
PERFORMANCE TESTS

4-1. INTRODUCTION

The procedures in this section test the instrument's electrical performance using the specifications of Table 1-1 as the performance standards. All tests can be performed without access to the interior of the instrument. A simpler operational test is included in Section III under Basic Functional Checks.

NOTE

A 30 minute warm-up period is required before any tests are performed.

Line voltage must be within +5% and −10% of nominal if the performance tests are to be considered valid.

4-2. EQUIPMENT REQUIRED

Equipment required for the performance tests is listed in Table 1-4, Recommended Test Equipment in Section I. Any equipment that satisfies the critical specifications given in the table may be substituted for the recommended model(s).

4-3. TEST RECORD

Results of the performance tests may be tabulated on the Test Record at the end of the procedures. The Test Record lists all of the tested specifications and their acceptable limits. The results, recorded at incoming inspection, can be used for comparison in periodic maintenance and troubleshooting and after repairs or adjustments.

4-4. CALIBRATION CYCLE

This instrument requires periodic verification of performance. Depending on the use and environmental conditions, the instrument should be checked using the following performance tests at least once every year.

PERFORMANCE TESTS

4-5. MEASUREMENT FREQUENCY RANGE, IF OUTPUT BANDWIDTH AND LEVEL PEFORMANCE TESTS

Specifications

Electrical Characteristics	Performance Limits	Conditions
TEST SIGNAL		
Frequency Range[1]	10 MHz to 18 GHz	External low-pass filtering may be required for test signals <20 MHz and ±20 MHz around band centers.
Band Center Frequencies	1.92 GHz 4.48 GHz 7.04 GHz 9.60 GHz 12.16 GHz 14.72 GHz 17.48 GHz	
IF OUTPUT		
Bandwidth	5 MHz to 1280 MHz	
Level	+7 dBm Minimum	

[1]Frequency range covered in eight bands, excluding ±5 MHz around band center frequencies.

PERFORMANCE TESTS

MEASUREMENT FREQUENCY RANGE, IF OUTPUT BANDWIDTH AND LEVEL PERFORMANCE TEST (cont'd)

Description This test verifies the frequency range of the Carrier Noise Test Set. A microwave test signal is input to the Carrier Noise Test Set for each BAND RANGE; then the down converted IF OUTPUT is measured on a spectrum analyzer. The IF OUTPUT level is verified to be within specified limits for each band.

Equipment

Microwave Synthesized Source ...... HP 8340A
RF Spectrum Analyzer .... HP 8566B
RF Synthesized
 Signal Generator .... HP 8662A

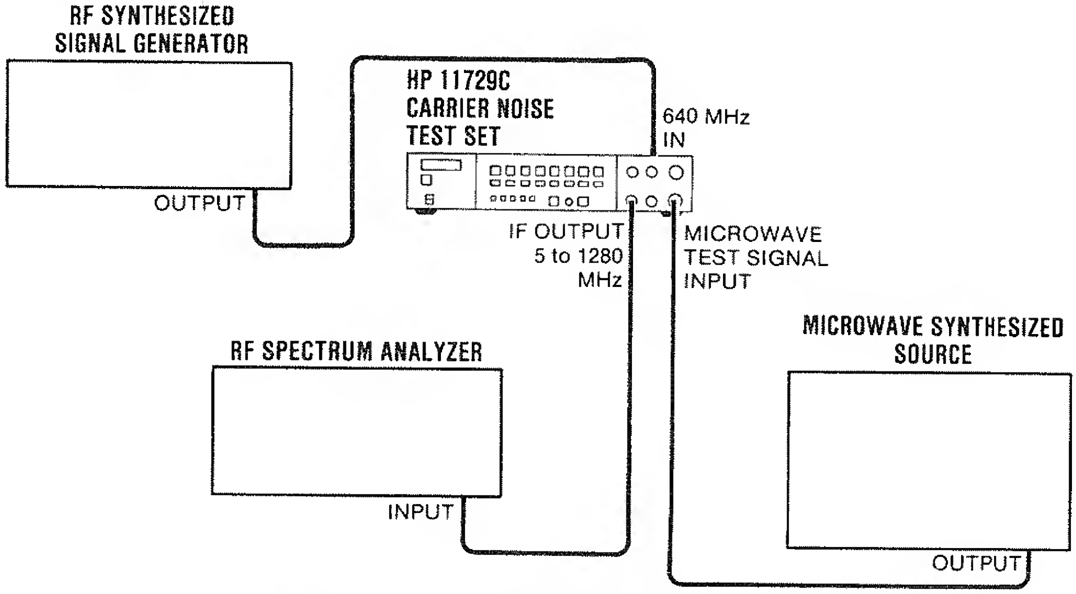


Figure 4-1. Measurement Frequency Range, and IF Output Bandwidth and Level Test Set-up

Procedure

1. Connect the test set up shown in Figure 4-1.
2. Set the Carrier Noise Test Set as follows:

   Band Center Frequency .... 1.92 GHz

   NOTE

   If the unit does not contain a filter with this band center frequency, select the next available band listed in column 2 of Table 4-1.

3. Set the Microwave Synthesized Source (D.U.T.) as follows:

   Frequency .... 2.32 GHz
   Amplitude .... +10 dBm

   NOTE

   The frequency corresponds to the microwave test signal shown in Table 4-1 for the band center frequency selected in step 2.

PERFORMANCE TESTS

MEASUREMENT FREQUENCY RANGE, IF OUTPUT BANDWIDTH AND LEVEL PERFORMANCE TESTS (cont'd)

Procedure (cont'd)

4. Adjust the RF spectrum analyzer to display the 400 MHz IF OUTPUT.

NOTE

The IF OUTPUT will have the following signals:

- The IF signal (the microwave test signal minus the band center of the band range chosen.)

- IF harmonics

- And spurious signals

ALL HARMONICS OF THE IF SIGNAL AND ANY SPURIOUS SIGNALS CAN BE DISREGARDED.

5. Verify the IF OUTPUT level is within the specified limits in Table 4-1 and record the actual value.

6. Adjust the frequency of the D.U.T. to the next microwave test signal frequency listed in column one of Table 4-1. Select the corresponding band center frequency, on the Carrier Noise Test Set, listed in column two. Verify and record the IF OUTPUT power level. Repeat this process for each microwave test signal frequency listed in Table 4-1.

7. If the IF OUTPUT power level did not measure within specified limits, refer to the troubleshooting information on Service Sheet 1.

Table 4-1. IF Output Level

Microwave Test Signal (GHz)	Band Center Frequency (GHz)	IF Output Frequency (MHz)	IF Output Level (dBm)	
		Typical	Minimum	Actual
2.32	1.92	400	+7	______
4.88	4.48	400	+7	______
7.44	7.04	400	+7	______
10.00	9.60	400	+7	______
12.56	12.16	400	+7	______
*14.740	14.72	20	+7	______
*16.00	14.72	1280	+7	______
*17.30	17.28	20	+7	______
*18.56	17.28	1280	+7	______

*Because of the power requirements of the internal mixer, the upper and lower ends of the bands with center frequencies of 14.72 GHz and 17.28 GHz are verified to be within specified limits. The comb generator's output power is lowest at the higher 640 MHz harmonics.

PERFORMANCE TESTS

4-6. RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal less than 1280 MHz)

Specification

Electrical Characteristics	Performance Limits	Conditions
Offset From Carrier	dBc/Hz	With a <1.28 GHz input signal
10 Hz	−115	
100 Hz	−126	
1 kHz	−135	
10 kHz	−142	
100 kHz	−151	
1 MHz	−156	

Description

NOTE

This test does not check the down converting circuitry in the Carrier Noise Test Set. However, the test requires less equipment than the residual phase noise test using a 10 GHz test signal.

The Carrier Noise Test Set's residual phase noise,for test signals <1280 MHz, is verified by connecting a signal generator's RF output to a power splitter. The output of the power splitter supplies the signals for both the MICROWAVE TEST SIGNAL INPUT and the 5—1280 MHz INPUT. Since the microwave test signal and the 5—1280 MHz signal are identical, the phase noise from the signal generator is canceled by the mixer/phase detector in the Carrier Noise Test Set. During the residual phase noise measurement the microwave test signal and the 5—1280 MHz signal must be in phase quadrature (that is,90 degrees out of phase). The difference in the lengths of cables A and B provide a time delay,so at a selected frequency on the signal generator the two inputs will have a 90 degree phase difference. The Carrier Noise Test Set's NOISE SPECTRUM OUTPUTS are measured on a low frequency spectrum analyzer and an RF spectrum analyzer. Correction factors are added and the residual phase noise is verified to be below the specified limit.

Equipment

RF Synthesized Signal Generator .... HP 8662A (Option 003)
Low Frequency Spectrum Analyzer .... HP 3582A
RF Spectrum Analyzer .... HP 8566B
Power Meter .... HP 436A
Power Sensor .... HP 8482A
Power Splitter .... HP 11667A
Coaxial Cable A (9 inches) .... HP 10502A
Coaxial Cable B (24 inches) .... HP 11170B
50Ω Termination .... HP 11593A

NOTE

The specified lengths of cable A and cable B in Figure 4-2 are critical for obtaining phase quadrature.

PERFORMANCE TESTS

RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal less than 1280 MHz) (cont'd)

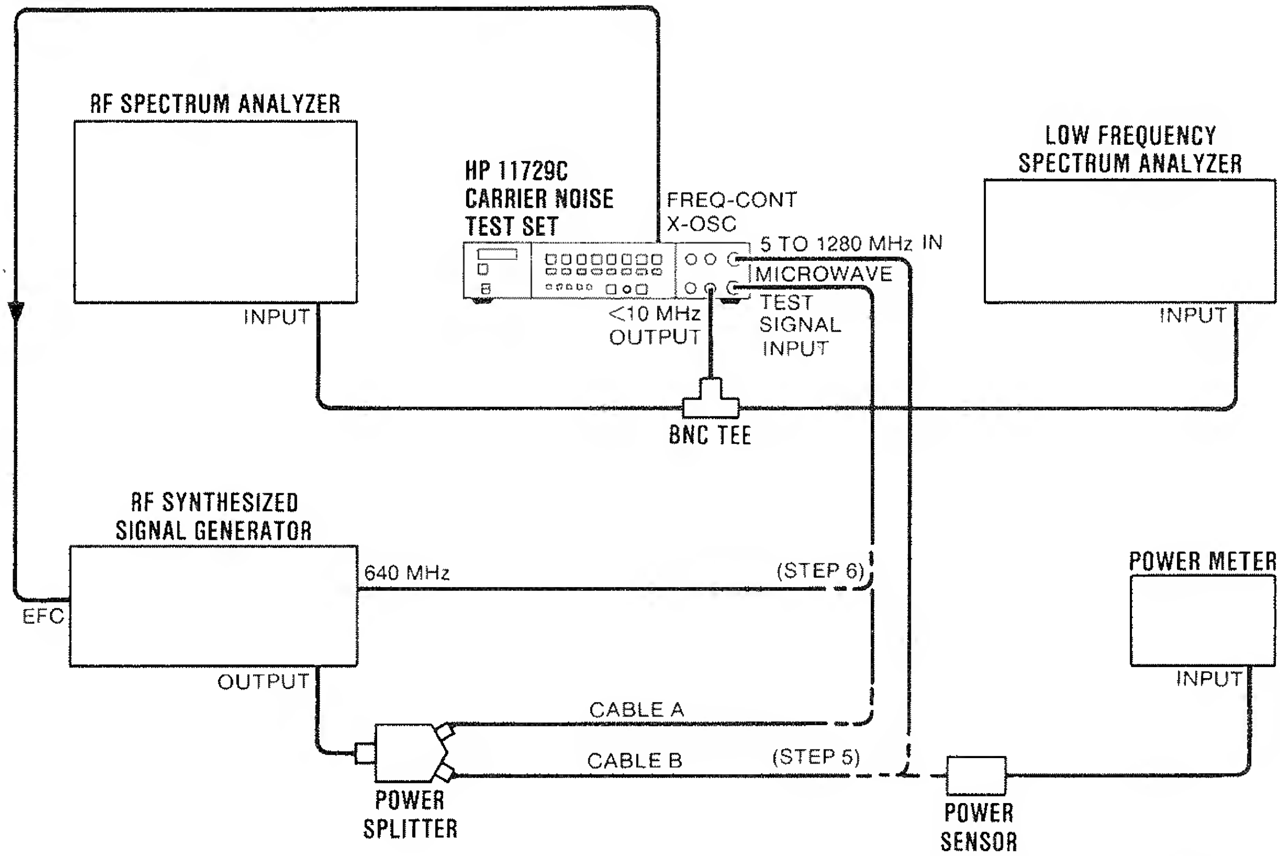


Figure 4-2. Residual Phase Noise Test Setup (Using a test signal of less than 1280 MHz)

Procedure

Calibration

1. Connect the instruments as shown in Figure 4-2.

2. Turn on and warm up all instruments in the test setup for 30 minutes.

3. Set the RF synthesized signal generator (tunable reference) as follows:

   Frequency .... 639.990 MHz
   Amplitude .... 0 dBm

4. Set the Carrier Noise Test Set as follows:

   Band Range .... 0.01 to 1.28 GHz
   Measurement Mode .... ϕ, CW
   Lock Bandwidth Factor .... Any setting

5. Measure the power of the tunable reference signal at the end of cable B and adjust the amplitude of the tunable reference until the power meter reads 0 dBm. Connect cable B to the 5—1280 MHz INPUT on the Carrier Noise Test Set.

PERFORMANCE TESTS

RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal less than 1280 MHz) (cont'd)

Procedure (cont'd)

6. Disconnect cable A from the MICROWAVE TEST SIGNAL INPUT on the Carrier Noise Test Set and terminate cable A with a 50 ohm load. Connect the 640 MHz signal, from the tunable reference rear panel, to the MICROWAVE TEST SIGNAL INPUT, on the front panel,of the Carrier Noise Test Set.

7. Decrease the amplitude of the tunable reference by 50 dB.

8. Adjust the RF spectrum analyzer to display the 10 kHz beat note. (The beat note is the result of mixing the 640 MHz and 639.990 MHz signals). Set the 10 kHz beat note to a convenient reference point.

9. Adjust the low frequency spectrum analyzer to view the 10 kHz beat note. If the spectrum analyzer has selectable filters, select a flat top filter. If RMS averaging is available, select approximately 128 averages. RMS averaging smooths out the noise floor. If RMS averaging is not available the measurement should be made at an average level on the noise floor, not a peak or valley.

10. Set the peak of the 10 kHz beat note to a convenient reference point.

11. Disconnect the 640 MHz signal from the MICROWAVE TEST SIGNAL INPUT on the Carrier Noise Test Set. Disconnect the 50 ohm load from cable A and connect cable A to the MICROWAVE TEST SIGNAL INPUT.

Residual Phase Noise Measurement

12. Increase the amplitude of the tunable reference by 50 dB. Decrease the frequency of the tunable reference, in 1 MHz steps,until phase lock is acquired (green LED is illuminated on the phase lock display). The green LED should be illuminated when the tunable reference is around 425 MHz. For details on phase locking see Section III.

13. Adjust the RF spectrum analyzer to view the noise level at a 10 kHz offset. For the most accurate measurement use the smallest possible resolution bandwidth. Use some averaging to smooth out the noise level. Measure the noise level down from the reference point at 10 kHz. Measure an average noise level, do not measure on a peak or minimum noise level. Record this noise level (A) along with the spectrum analyzer's resolution bandwidth setting (B) below. Repeat the measurement and record for offsets of 100 kHz and 1 MHz.

Offset from carrier	Noise level (A) (relative to reference level) (dB)	Resolution Bandwidth (B) (Hz)
10 kHz	______	______
100 kHz	______	______
1 MHz	______	______

PERFORMANCE TESTS

RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal less than 1280 MHz) (cont'd)

Procedure (cont'd)

14. On the low frequency spectrum analyzer, select a Hanning filter and the normalization to 1 Hz bandwidth (if the spectrum analyzer has these features available). If the spectrum analyzer does not have the normalization to a 1 Hz bandwidth this figure will have to be calculated later using the formula at the end of the test.

NOTE

Power line spurs are not specified for the Carrier Noise Test Set. Power line spurs will appear at power line frequencies and multiples of power line frequencies. Do not make a noise measurement on a spur; make the measurement on an average noise level.

15. Adjust the low frequency spectrum analyzer to view the noise level at a 10 Hz offset. For the most accurate measurement use the smallest possible resolution bandwidth. Use some averaging if required. Measure the noise level down from the reference point at 10 Hz. Measure an average noise level, do not measure on a peak or minimum noise level. Record this noise level (C) in the table below. If the measurement was not made in a 1 Hz resolution bandwidth, also record the spectrum analyzer's resolution bandwidth setting (D) below. Repeat the measurement and record for offsets of 100 Hz and 1 kHz.

Offset from carrier	Noise level (C) (relative to reference level) (dB)	Resolution Bandwidth (D) (Hz)
10 Hz	__________	__________
100 Hz	__________	__________
1 kHz	__________	__________

16. Calculate the Carrier Noise Test Set's residual phase noise at 10 kHz, 100 kHz and 1 MHz offsets from the carrier. Sum the measured noise level (A) and the 4 correction factors as shown below. The normalization bandwidth factor is determined by putting the resolution bandwidth (B) into the equation below. Verify the residual phase noise level did not exceed the specified limit, as shown at the bottom of each column.

[2] For a complete explanation of the correction factors see Appendix A.

PERFORMANCE TESTS

RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal less than 1280 MHz) (cont'd)

Procedure (cont'd)

	10 kHz	100 kHz	1 MHz
Noise level = A (relative to reference level)	________ dB	________ dB	________ dB
Normalization to 1 Hz equivalent noise bandwidth[1] −10 log ("B" x 1.2) =	________ dB	________ dB	________ dB
Calibration Attenuation (Step 7)	−50 dB	−50 dB	−50 dB
£ (f) conversion factor	−6 dB	−6 dB	−6 dB
Correction for log amplifiers and peak detectors in analog spectrum analyzers.	+2.5 dB	+2.5 dB	+2.5 dB
Total (dBc/Hz)	______ <−142	______ <−151	______ <−156

[1]Refer to Application Note 150-4, HP 5952-1147, if additional information on calibration of spectrum analyzers for noise measurements is needed.

17. Calculate the Carrier Noise Test Set's residual phase noise at 10 Hz, 100 Hz and 1 kHz offsets from the carrier. Sum the measured noise level (C) and the 3 correction factors[2] as shown below. Do not add the normalization to 1 Hz equivalent noise bandwidth factor, when using a spectrum analyzer with normalization to a 1 Hz bandwidth. This correction factor is accounted for automatically. Verify the residual phase noise level did not exceed the specified limit as shown at the bottom of each column.

	10 Hz	100 Hz	1 kHz
Noise level = C (relative to reference level)	________ dB	________ dB	________ dB
Normalization to 1 Hz equivalent noise bandwidth[1] −10 log ("B" x 1.2) =	________ dB	________ dB	________ dB
Calibration Attenuation (Step 7)	−50 dB	−50 dB	−50 dB
£ (f) conversion factor	−6 dB	−6 dB	−6 dB
Total (dBc/Hz)	______ <−115	______ <−126	______ <−135

[1]Refer to Application Note 150-4, HP 5952-1147, if additional information on calibration of spectrum analyzers for noise measurements is needed.

NOTE

If an analog spectrum analyzer was used to measure the noise floor at 10 Hz, 100 Hz, and 1 kHz, add +2.5 dB to the totals above as a correction for the log amplifiers and peak detectors in the analog spectrum analyzer.

[2]For a complete explanation of the correction factors see Appendix A.

PERFORMANCE TESTS

4-7. RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal of 10 GHz)

Specification

Electrical Characteristics	Performance Limits	Conditions
Offset From Carrier	dBc/Hz	With a 10 GHz input signal
10 Hz	−90	
100 Hz	−105	
1 kHz	−115	
10 kHz	−127	
100 kHz	−137	
1 MHz	−142	

Description

NOTE

This performance test is only necessary when the residual phase noise of the Carrier Noise Test Set is in question.

This test verifies the Carrier Noise Test Set's residual phase noise specifications using a 10 GHz test signal. A second Carrier Noise Test Set is required as a reference unit in this test. Since this test requires a second Carrier Noise Test Set, we recommend that the phase noise of the other instruments in the phase noise measuring system be checked before this test is performed.

During the residual phase noise measurement the microwave test signal and the 5—1280 MHz signal must be in phase quadrature (that is 90 degrees out of phase). One microwave synthesized source supplies the MICROWAVE TEST SIGNAL INPUT to both of the Carrier Noise Test Sets (device under test and reference). The IF OUTPUT of the reference Carrier Noise Test Set then supplies the 5—1280 MHz INPUT of the Carrier Noise Test Set device under test. The Carrier Noise Test Set's residual phase noise is measured on a low frequency spectrum analyzer and an RF spectrum analyzer. Correction factors are added and the residual phase noise is verified to be below the specified limit.

Equipment

Carrier Noise Test Set .... HP 11729C
(used as reference)
RF Synthesized Signal Generator .... HP 8662A (Option 003)
Microwave Synthesized Source .... HP 8340A
Low Frequency Spectrum Analyzer .... HP 3582A
RF Spectrum Analyzer .... HP 8566B
Power Meter .... HP 436A
Power Sensor .... HP 8482A
Power Splitter (quantity 2) .... HP 11667A
Amplifier .... HP 8447E/F
1 dB Step Attenuator (quantity 2) .... HP 355C

Procedure

Initial Instrument Settings

1. Connect the instruments as shown in Figure 4-3.
2. Turn on and warm-up the instruments for 30 minutes.
3. Set both step attenuators to maximum attenuation.

PERFORMANCE TESTS

RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal of 10 GHz) (cont'd)

Procedure (cont'd)

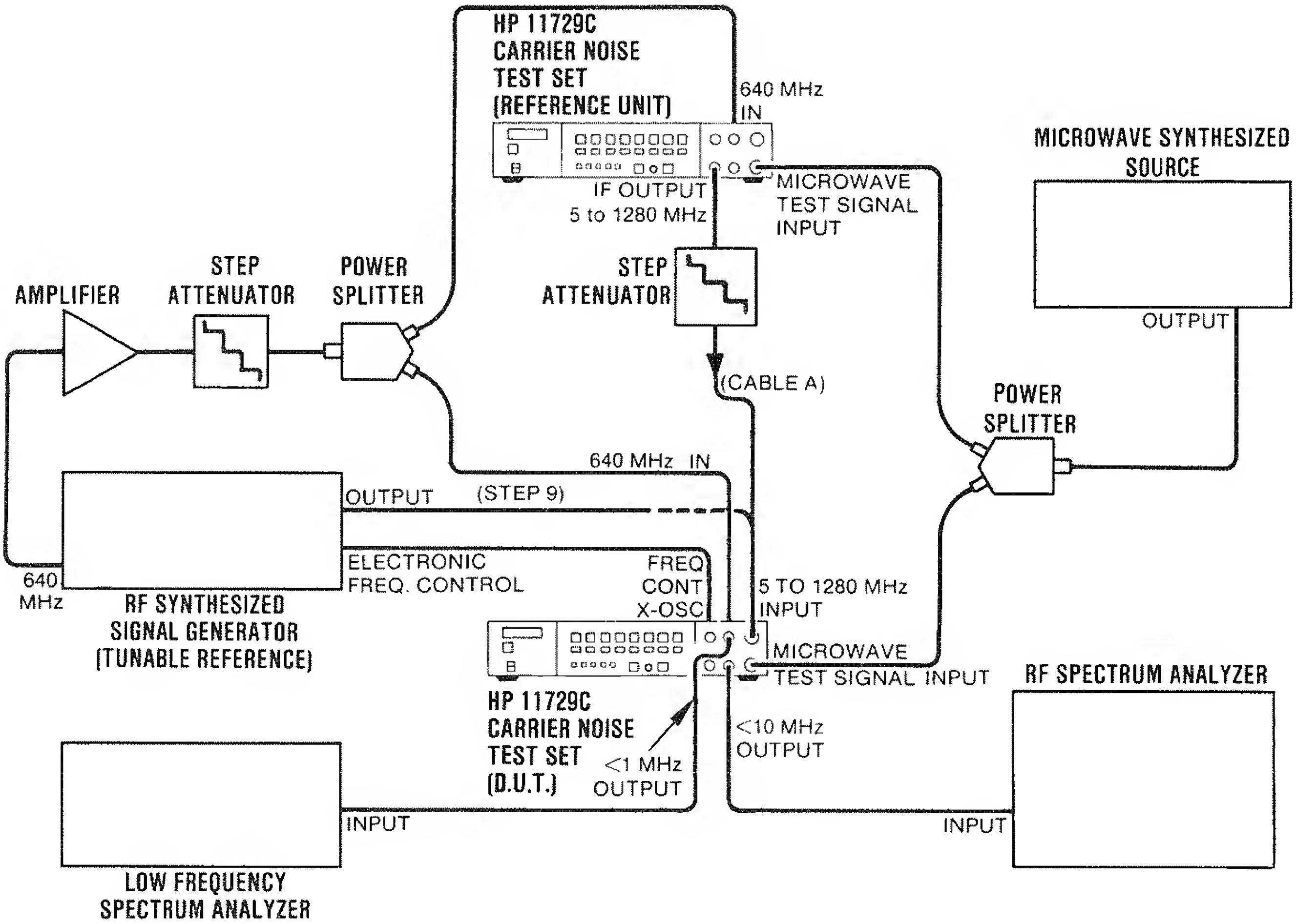


Figure 4-3. Residual Phase Noise Test Setup (Using a Test Signal of 10 GHz)

4. Set the Microwave Synthesized Soruce as follows:

   Frequency .... 10 GHz
   Output Level .... +10 dBm to +20 dBm

5. Set the RF Synthesized Signal Generator (tunable reference) as follows:

   Frequency .... 399.990 MHz
   Output Level .... 0 dBm

6. Set both Carrier Noise Test Sets as follows:

   Band Center Frequency .... 9.6 GHz
   Lock Bandwidth Factor 1
   Measurement Mode .... ϕ, CW

PERFORMANCE TESTS

RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal of 10 GHz) (cont'd)

Procedure (cont'd)

Power Level Checks

7. Disconnect the cable which goes to the 640 MHz IN connector on the rear panel of the Carrier Noise Test Set device under test. Connect the power sensor to this cable. Adjust the step attenuator that is located before the power splitter, supplying the 640 MHz signal, such that the power meter reads between 0 dBm and +3 dBm. Reconnect the cable to the 640 MHz INPUT, on the rear panel, of Carrier Noise Test Set device under test.

8. Disconnect the end of cable A which is connected to the 5—1280 MHz INPUT on the Carrier Noise Test Set device under test. Connect the cable to a power sensor. Measure the IF OUTPUT power. Adjust the 1 dB step attenuator located after the IF OUTPUT of the reference Carrier Noise Test Set until the power meter reads −1 dBm to 0 dBm. Record the exact power meter reading below.

   Reference Carrier Noise Test Set IF OUTPUT power = ________ dBm

Spectrum Analyzer Calibration

9. Disconnect cable A from the power sensor. Connect the cable from the tunable reference output to the power sensor. Adjust the amplitude of the tunable reference until the power meter reads the power level recorded in step 8. Connect the tunable reference to the 5—1280 MHz INPUT on the Carrier Noise Test Set device under test.

10. Decrease the amplitude of the tunable reference by 50 dB. Adjust the RF spectrum analyzer to display the approximately 10 kHz beat note. (The beat note is the result of mixing the 400 MHz IF (MICROWAVE TEST SIGNAL INPUT minus the band center of the BAND RANGE chosen) and the 399.990 MHz tunable reference signal). Set the peak of the 10 kHz beat note to a convenient reference point.

11. Adjust the low frequency spectrum analyzer to view the approximately 10 kHz beat note. If the spectrum analyzer has selectable filters, select a flat top filter. If RMS averaging is available, select approximately 128 averages. RMS averaging smooths out the noise floor. If RMS averaging is not available the measurement should be made at an average level on the noise floor, not on a peak or valley.

12. Set the peak of the beat note to a convenient reference point.

Residual Phase Noise Measurement

13. Disconnect the tunable reference from the 5 to 1280 MHz INPUT on the Carrier Noise Test Set device under test. Reconnect cable A to the 5—1280 MHz INPUT on the Carrier Noise Test Set device under test.

14. Decrease the frequency of the Microwave Synthesized Source in 1 MHz steps, until the Carrier Noise Test Set device under test indicates phase quadrature (green LED is illuminated on the phase lock display.) Details of phase locking are found in Section III.

PERFORMANCE TESTS

RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal of 10 GHz) (cont'd)

Procedure (cont'd)

15. Adjust the RF spectrum analyzer to view the residual phase noise level at a 10 kHz offset from the carrier. For the most accurate measurement, use the smallest possible resolution bandwidth. Use averaging if required. Measure the residual phase noise level down from the reference point. Measure on an average phase noise level, do not measure on a peak or minimum phase noise level. Record the phase noise level (A) along with the measurement resolution bandwidth (B) below. Repeat this measurement for offsets of 100 kHz and 1 MHz.

Offset from carrier	Noise level (A) (relative to reference level) (dB)	Resolution Bandwidth (B) (Hz)
10 kHz	______	______
100 kHz	______	______
1 MHz	______	______

16. On the low frequency spectrum analyzer, select a Hanning filter and the normalization to a 1 Hz bandwidth (if these features are available). If the spectrum analyzer does not have the feature for normalization to a 1 Hz bandwidth this figure will have to be calculated later using the formula at the end of the test.

17. Adjust the low frequency spectrum analyzer to view the residual phase noise level at 10 Hz. Measure the residual phase noise level down from the reference point. Measure on an average phase noise level; do not measure on a peak or minimum level.

NOTE

Power line spurs are not specified for the Carrier Noise Test Set. Power line spurs will appear at power line frequencies and multiples of power line frequencies. Do not make a phase noise measurement on a spur, make the measurement on an average noise level.

18. Record the phase noise level (C) below. If the measurement was not made in a 1 Hz resolution bandwidth, also record the measurement resolution bandwidth (D). Repeat this measurement at 100 Hz and 1 kHz offsets.

Offset from carrier	Noise level (C) (relative to reference level) (dB)	Resolution Bandwidth (D) (Hz)
10 Hz	______	______
100 Hz	______	______
1 kHz	______	______

19. Calculate the residual phase noise of the Carrier Noise Test Set at 10 kHz, 100 kHz and 1 MHz offsets from the carrier. Sum the measured phase noise level (A) and the 4 correction factors[2] listed below. The normalization bandwidth factor is determined by putting the resolution bandwidth (B) into the equation below. Verify the residual phase noise level did not exceed the specified limit as shown at the bottom of each column.

[2]For a complete explanation of the correction factors see Appendix A.

PERFORMANCE TESTS

RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a test signal of 10 GHz) (cont'd)

Procedure (cont'd)

	10 kHz	100 kHz	1 MHz
Noise level = A (relative to reference level)	_______ dB	_______ dB	_______ dB
Normalization to 1 Hz equivalent noise bandwidth[1] −10 log ("B" x 1.2) =	_______ dB	_______ dB	_______ dB
Calibration Attenuation (Step 10)	−50 dB	−50 dB	−50 dB
$\mathcal{L}$(f) conversion factor	−6 dB	−6 dB	−6 dB
Correction for log amplifiers and peak detectors in analog spectrum analyzer	+2.5 dB	+2.5 dB	+2.5 dB
Total (dBc/Hz)	_______ <−127	_______ <−137	_______ <−142

[1]Refer to Application Note 150-4, HP 5952-1147, if additional information on calibration of spectrum analyzers for noise measurements is needed.

20. Calculate the residual phase noise level of the Carrier Noise Test Set at 10 Hz, 100 Hz and 1 kHz offsets from the carrier. Sum the measured phase noise level (C) and the 3 correction factors[2] below. Do not add the normalization to a 1 Hz equivalent noise bandwidth factor, when the spectrum analyzer accounts for this factor automatically. Verify the residual phase noise level does not exceed the specified limit shown at the bottom of each column.

	10 Hz	100 Hz	1 kHz
Noise level = C (relative to reference level)	_______ dB	_______ dB	_______ dB
Normalization to 1 Hz equivalent noise bandwidth[1] −10 log ("D" x 1.2) =	_______ dB	_______ dB	_______ dB
Calibration Attenuation (Step 10)	−50 dB	−50 dB	−50 dB
$\mathcal{L}$(f) conversion factor	−6 dB	−6 dB	−6 dB
Total (dBc/Hz)	_______ <−90	_______ <−105	_______ <−115

[1]Refer to Application Note 150-4, HP 5952-1147, if additional information on calibration of spectrum analyzers for noise measurements is needed.

NOTE

If an analog spectrum analyzer was used to measure the noise floor at 10 Hz, 100 Hz and 1 kHz add +2.5 dB to the totals above. This is the correction factor for the log amplifiers and peak detectors in the analog spectrum analyzer.

[2]For a complete explanation of the correction factors see Appendix A.

PERFORMANCE TESTS

4-8. AM NOISE FLOOR PERFORMANCE TEST

Specification

Electrical Characteristics	Performance Limits	Conditions
AM Noise Floor Offset from Carrier	AM Noise (dBc/Hz)	At +10 dBm input level
1 kHz	−138	
10 kHz	−145	
100 kHz	−155	
1 MHz	−160	

Description

NOTE

This test, as written, is only a partial verification of the AM Noise floor specification. The test only verifies the AM noise floor for frequency offsets of 100kHz and higher. From 1Hz to 100kHz the recommended low noise oscillator's AM noise floor is higher than the AM noise floor of the Carrier Noise Test Set. For a complete verification, an oscillator with lower AM noise specifications than the Carrier Noise Test Set would be needed.

The AM noise floor is measured at two offsets from the carrier (100 kHz and 1 MHz) to verify AM noise detection is performing within limits. A signal generator is used for calibrating the spectrum analyzer. A low noise oscillator is connected to the MICROWAVE TEST SIGNAL INPUT for the AM noise measurement. The AM noise floor is observed from the <10 MHz OUTPUT on a spectrum analyzer.

Equipment

Microwave Synthesized Source .... HP 8340A
(with AM modulation)
Spectrum Analyzer .... HP 8566B
Function Generator .... HP 3312A
Coaxial to waveguide adapter .... HP X281A
*Isolator .... HP 0955-0178
Power Supply .... HP 6214B
Power Meter .... HP 436A
Power Sensor .... HP 8481A
Low Noise Oscillator .... MA 86651A

*The isolator stabilizes load effects on the AM noise floor. When an isolator is not available an attenuator pad may be used. The attenuator pad may be used only if the output power of the oscillator is +10 dBm with the attenuator pad in place. If the measured power is +10 dBm or lower an isolator will have to be used. (See step 5 of the test procedure)

Procedure

Calibration

1. Connect the equipment as shown in Figure 4-4.

2. Connect +10 Vdc from the power supply to the low noise oscillator. Warm up the oscillator for 30 minutes.

PERFORMANCE TESTS

AM NOISE FLOOR PERFORMANCE TEST (cont'd)

Procedure (cont'd)

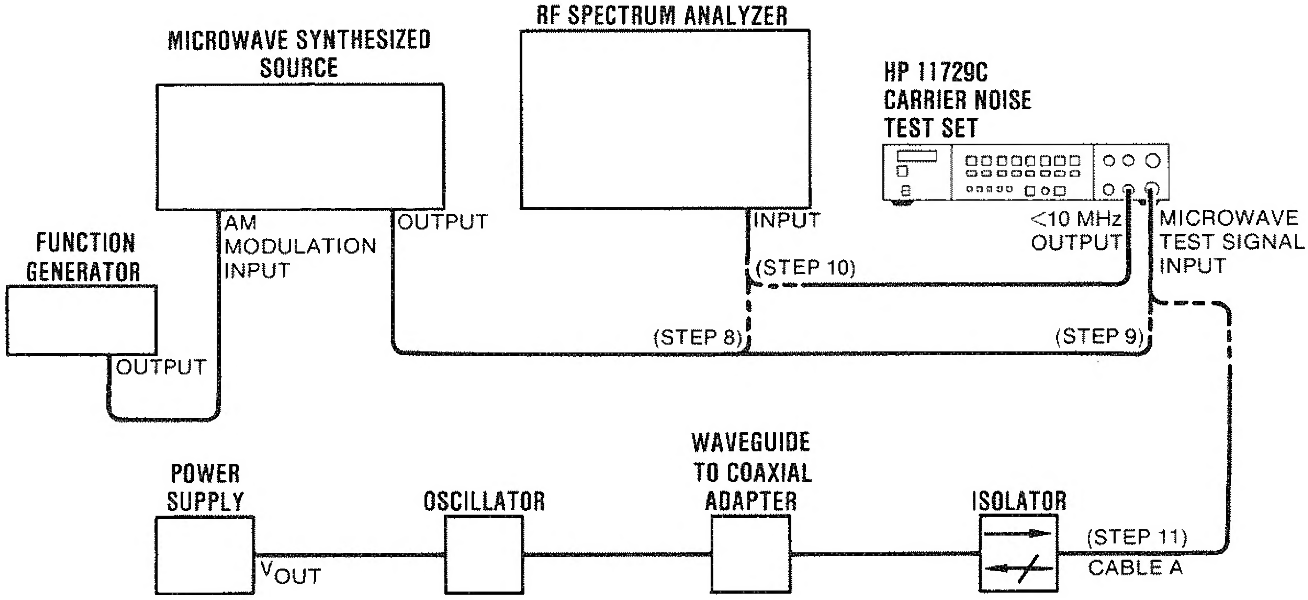


Figure 4-4. AM Noise Floor Test Set-up

3. Set the Microwave Synthesized Source as follows:

   Frequency .... 1 GHz
   AM modulation 50%

4. Set the function generator as follows:

   Function .... sinewave
   Frequency .... 100 kHz

5. Set the Carrier Noise Test Set as follows:

   Measurement Mode .... AM, CW
   All other controls .... Any setting

6. Measure the power level of the low noise oscillator at the end of cable A (the end that connects to the MICROWAVE TEST SIGNAL INPUT). The level should be approximately +10 dBm. Connect an attenuator pad at the oscillator's output if the power level is above +10 dBm. The value of the attenuator pad selected should bring the measured power level to +10 dBm. Disconnect cable A from the power sensor.

   Record the power level below.

   Low noise oscillator power level ________ dBm

PERFORMANCE TESTS

AM NOISE FLOOR PERFORMANCE TEST (cont'd)

Procedure (cont'd)

NOTE

The AM noise floor of the Carrier Noise Test Set is specified for a +10 dBm input level. Using an input signal lower than +10 dBm will increase the AM noise floor. The noise floor will increase by the amount in dB that the input signal was lowered from +10 dBm. As an example: a +7 dBm input will raise the AM noise floor by +3 dB.

Because our specifications are higher than typical measured values, an input signal of +5 dBm minimum will typically still measure within specifications.

7. Connect the end of the cable from the Microwave Synthesized Source to the power sensor. Adjust the amplitude of the Microwave Synthesized Source until the power meter reads the power level recorded in step 6.

8. Turn the Microwave Synthesized Source to external AM modulation. Connect the Microwave Synthesized Source to the spectrum analyzer. Be sure the input to the spectrum analyzer is 50 ohms.

9. Adjust the amplitude on the function generator so the sidebands displayed on the spectrum analyzer are −40 dBc. Disconnect the Microwave Synthesized Source from the spectrum analyzer and connect it to the Carrier Noise Test Set MICROWAVE TEST SIGNAL INPUT.

10. Connect the <10 MHz OUTPUT from the Carrier Noise Test Set to the spectrum analyzer. Adjust the spectrum analyzer to view the 100 kHz sidebands on the 1 GHz signal. Set the peak of the 100 kHz signal to a convenient reference point.

AM Noise Floor Measurement

11. Disconnect the Microwave Synthesized Source from the MICROWAVE TEST SIGNAL INPUT. Connect the output of the low noise oscillator to the MICROWAVE TEST SIGNAL INPUT.

NOTE

The oscillator signal should come directly from the resonator with no amplification stage in between. Under this condition, it is likely that the AM noise coming from the oscillator is less than or equal to −155 dBc/Hz at a 100 kHz offset.

12. Measure the noise level down from the reference point at a 100 kHz offset. Record the AM noise level (A) and resolution bandwidth (B) below. Measure the AM noise floor at a 1 MHz offset. Record this level with the corresponding resolution bandwidth below.

Offset from carrier	Noise level (A) (relative to reference level) (dB)	Resolution Bandwidth (B) (Hz)
100 kHz	________	________
1 MHz	________	________

PERFORMANCE TESTS

AM NOISE FLOOR PERFORMANCE TEST (cont'd)

Procedure (cont'd)

13. Calculate the AM noise floor by summing the measured AM noise level (A) and the 3 correction factors[2] shown below. The normalization bandwidth factor is determined by putting the resolution bandwidth (B) into the equation below. Verify the AM noise floor did not exceed the specified limit as shown at the bottom of each column.

	100 kHz	1 MHz
Noise level = A (relative to reference level)	______ dB	______ dB
Normalization to 1 Hz equivalent noise bandwidth[1] −10 log ("B" x 1.2) =	______ dB	______ dB
Calibration Attenuation (Step 8)	−40 dB	−40 dB
Correction for log amplifiers and peak detectors in analog spectrum analyzer	+2.5 dB	+2.5 dB
Total (dBc/Hz)	______ <−155	______ <−160

[1] Refer to Application Note 150-4, HP 5952-1147, if additional information on calibration of spectrum analyzers for noise measurements is needed.

[2] For a complete explanation of the correction factors see Appendix A.

Table 4-2. Performance Test Record

Hewlett-Packard Company Model HP 11729C Carrier Noise Test Set	Test by ______
Serial Number ______	Date ______

Para No.	Test Description			Results Min.	Results Actual	Results Max.
4-5.	MEASUREMENT FREQUENCY RANGE, IF OUTPUT BANDWIDTH AND LEVEL PERFORMANCE TEST					
	IF Output Power					
	Mirowave Signal (GHz)	Band Center (GHz)	IF Output Freq. (MHz) Typ.			
	2.32	1.92	400	+7 dBm	______	
	4.88	4.48	400	+7 dBm	______	
	7.44	7.04	400	+7 dBm	______	
	10.00	9.60	400	+7 dBm	______	
	12.56	12.16	400	+7 dBm	______	
	14.740	14.72	20	+7 dBm	______	
	16.00	14.72	1280	+7 dBm	______	
	17.30	17.28	20	+7 dBm	______	
	18.56	17.28	1280	+7 dBm	______	
4-6.	RESIDUAL PHASE NOISE PERFORMANCE TEST (Using a <1280 MHz Test Signal)					
	Offset From The Carrier				(dBc/Hz)	(dBc/Hz)
		10 Hz			______	−115
		100 Hz			______	−126
		1 kHz			______	−135
		10 kHz			______	−142
		100 kHz			______	−151
		1 MHz			______	−156
4-7.	RESIDUAL PHASE NOISE PERFORMANCE (Using a 10 GHz Test Signal)					
	Offset From The Carrier				(dBc/Hz)	(dBc/Hz)
		10 Hz			______	−90
		100 Hz			______	−105
		1 kHz			______	−115
		10 kHz			______	−127
		100 kHz			______	−137
		1 MHz			______	−142
4-8.	AM NOISE PERFORMANCE TEST					
	Offset From The Carrier				(dBc/Hz)	(dBc/Hz)
		100 kHz			______	−155
		1 MHz			______	−160